PETER NICHOLSON, ESQ:
ARCHITECT.
Author of the New Carpenters Guide, &c. &c.

THE

Carpenter and Joiner's Assistant;

CONTAINING

PRACTICAL RULES

FOR

MAKING ALL KINDS OF JOINTS, AND VARIOUS METHODS OF HINGEING THEM TOGETHER;

FOR HANGING OF DOORS ON STRAIGHT OR CIRCULAR PLANS;

FOR FITTING UP WINDOWS AND SHUTTERS TO ANSWER VARIOUS PURPOSES, WITH RULES FOR HANGING THEM:

For the Construction of *Floors*, *Partitions*, *Soffits*, *Groins*, *Arches for Masonry*; for constructing *Roofs* in the best Manner from a given Quantity of Timber:

For placing of *Bond Timbers*; with various Methods for adjusting *Raking Pediments*, enlarging and diminishing of Mouldings; *taking Dimensions* for Joinery, and for setting out *Shop Fronts*.

With a new Scheme for constructing *Stairs* and *Hand-rails*, and for Stairs having a Conical Well-hole, &c. &c.

TO WHICH ARE ADDED,

EXAMPLES OF VARIOUS ROOFS EXECUTED,

WITH THE SCANTLINGS, FROM ACTUAL MEASUREMENTS,

With RULES for MORTICES and TENONS, and for fixing IRON STRAPS, &c.

Also Extracts from *M. Belidor*, *M. du Hamel*, *M. de Buffon*, &c.

On the STRENGTH OF TIMBER, with Practical Observations.

Illustrated with SEVENTY-NINE PLATES, and copious Explanations.

By PETER NICHOLSON,

AUTHOR OF THE CARPENTER'S NEW GUIDE, &c.

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1797.

P R E F A C E.

IN my former publication, *The Carpenter's New Guide,* I have laid down and treated on many ufeful parts of the Carpenter and Joiner's profeffions; yet upon examination and reflection, there appeared various branches of which no notice had been taken by any author; and as fome of thefe are of confiderable importance and of frequent application, they appeared not unworthy of my attention and confideration; and the more fo, as it is neceffary thofe cafes fhould be beft underftood, which moft frequently arife in bufinefs: of thefe examples, which occur every day, is the major part of this book compofed; and which muft be confidered as a Supplement to, or Second Part of, the Carpenter's Guide, although in fome inftances the fame fubjects are again treated of in this book; of thefe I muft fay the examples are totally different, and the principles on which they are explained new, and in fome cafes better—and will I flatter myfelf tend to the eafe of the workman and the perfection of the work.

Of Soffits an entire new example is fhown for covering an oblique cone, which may be applied where the furface is any part of an oblique cone; the next example is for covering a foffit which is level at the crown and fluing upon the fides; and I muft obferve this method is preferable to my former one; yet neither of thefe problems will be abfolutely true in practice, as a plane furface can never apply with abfolute accuracy to fuch a winding furface; but either rule will anfwer the workman's purpofe.

On the fubjects of Groins or Crofs-arches, are given fome lines, the principles of which are entirely new and preferable for practice to any before publifhed. I have taken this opportunity of introducing fome new inventions applicable to Arches for Mafonry: on this fubject we have no inftructions in the Englifh language.

arithmetical rule, of consequence certain, and of general application; I have to lament that all my endeavours, assisted by several gentlemen well versed in mathematics, have hitherto been unsuccessful.—As the best substitute for a just rule for proportioning scantlings, I have subjoined examples of roofs of the best repute, with accurate measurements to the parts; some of these having stood the test of time, are entitled to great credit as examples; of these, the roof of St. Paul's Cathedral must certainly stand foremost, as well for magnitude as merit; of the others, some parts may justly be considered as beacons of caution, the dangers of which I have endeavoured to point out: of the more modern ones I have to observe, their magnitude call them into important notice, and from the principles on which they are constructed, I see no reason to doubt their durability. I beg leave here to return my thanks to the several Gentlemen who have favoured me with communications for this part of my work.

The roofs which I measured I have the satisfaction to say, were all in good repair and free from any cracks or flaws arising from unnecessary thrusts or transverse strains; nevertheless, these examples should not be followed without caution and consideration, as it is possible a roof may be too strong or heavy, as well as too weak; there are certain positions in which if the timbers are fixed, the number of braces may be lessened, and the scantling of the timbers be much reduced; which will occasion less stress upon the walls, and greatly lessen the expence of the work; nor should we ever despair of making advances in science.

Connected with Roofs are the subjects Mortices, Tenons, King-posts, Iron-straps, and Joggles for braces or struts, on which the practical Carpenter will find much useful information, tending to point out the construction, best adapted to their several circumstances.

As the Strength of Timber is to all practical Carpenters a subject of the first magnitude, at the conclusion of this work the reader will find much very important and useful information relative thereto, extracted from the works of the most celebrated mathematician and philosophers who have written on the subject; these principally are Frenchmen, and when I name M. Belidor, M. du Hamel, and M. de Buffon, nothing more need be said, only that their researches were aided by the liberality of the old French Government; for ample funds and apparatus, with the whole of the forests in France, were at their command, properly to investigate and to experiment this important branch of science: other great names are quoted, and upon the whole I have

On that important and intricate part of the bufinefs Stair-cafes, to which I have given particular application and attention, I have now the fatisfaction to make public, feveral great improvements and new articles. On Plate 60, is fhewn a method different from that in the Carpenter's Guide, for glueing up a rail in thicknefs, and which is plainer and more eafily underftood. Then follows a method accurate and true, for executing a Stair-cafe and Hand-rail, either out of the folid, or in thicknefs, when the well-hole is in the form of a fruftrum of a cone; a folution or true method for which has never been fhown in any work. Finally, there is a method for cutting the but-joints and for placing the falling mould to the folid piece after its being plumbed, a rule very much wanted in practice, and which will render the application of the moulds abfolutely certain.

Having thus enumerated the heads of contents of this part of the book, and pointed out their ufefulnefs in practice, it remains only for me to fay, that as in my former work I have united Theory and Practice, in this I have joined to the practical part fome ideas of Embellifhments, giving to the doors and windows the fafhionable mouldings, pannels and jambs.

It may be proper for me here again to obferve, that this book will not fuperfede or render ufelefs my former publication *The Carpenter's New Guide*, by no means; the fubjects, a few inftances only excepted, are totally different: the two volumes will form a complete treatife on the Carpenter and Joiner's bufinefs: befides, the Elements or Principles, as the bafis of practice, laid down in the beginning of the Carpenter's Guide, I earneftly recommend to be well underftood by every one who wifhes to attain to eminence and accuracy in the profeffion; for whoever fhall attempt the practical parts of the Carpenter's bufinefs without a due knowledge of the principles, will be like a fhip at fea without rudder or compafs, the port may be obtained, but the labour will be great and the event doubtful.

My endeavour has been to give articles of abfolute ufe only, for as to a number of curious fpeculations which rarely come into practice, I fee no end to inventing them; and I muft fay, that from my profeffional habits of teaching, I am but too well qualified to judge of the deficiency of young workmen, arifing from defect of education, or from juft principles having never been laid before them.

On that fubtile fubject, the proportional Strength of Timber, on which I gave fome obfervations and calculations in my Carpenter's Guide, I was in hopes that I fhould have been able to reduce the theory of fcantlings to an

arithmetical

much reaſon to hope, this part of my labours will be productive of much good to my countrymen and of praiſe to myſelf.

And here it is but juſtice to make my acknowledgments to the Encyclopædia Britannica, where, under the article Strength of Material, an ample diſcuſſion of this ſubject will be found, with all the mathematical demonſtrations neceſſary to the ſubject; forming a complete hiſtory of the reſearches which have been made by the various mathematicians and philoſophers of Europe on this intereſting ſubject.

To conclude, I have to hope, that what has been accumulated with no ſmall portion of labour and pains to me, will be attended with a correſponding benefit to the Public, this only will give an impetus ſufficient to carry me on in this intricate path of practical ſcience.

PETER NICHOLSON.

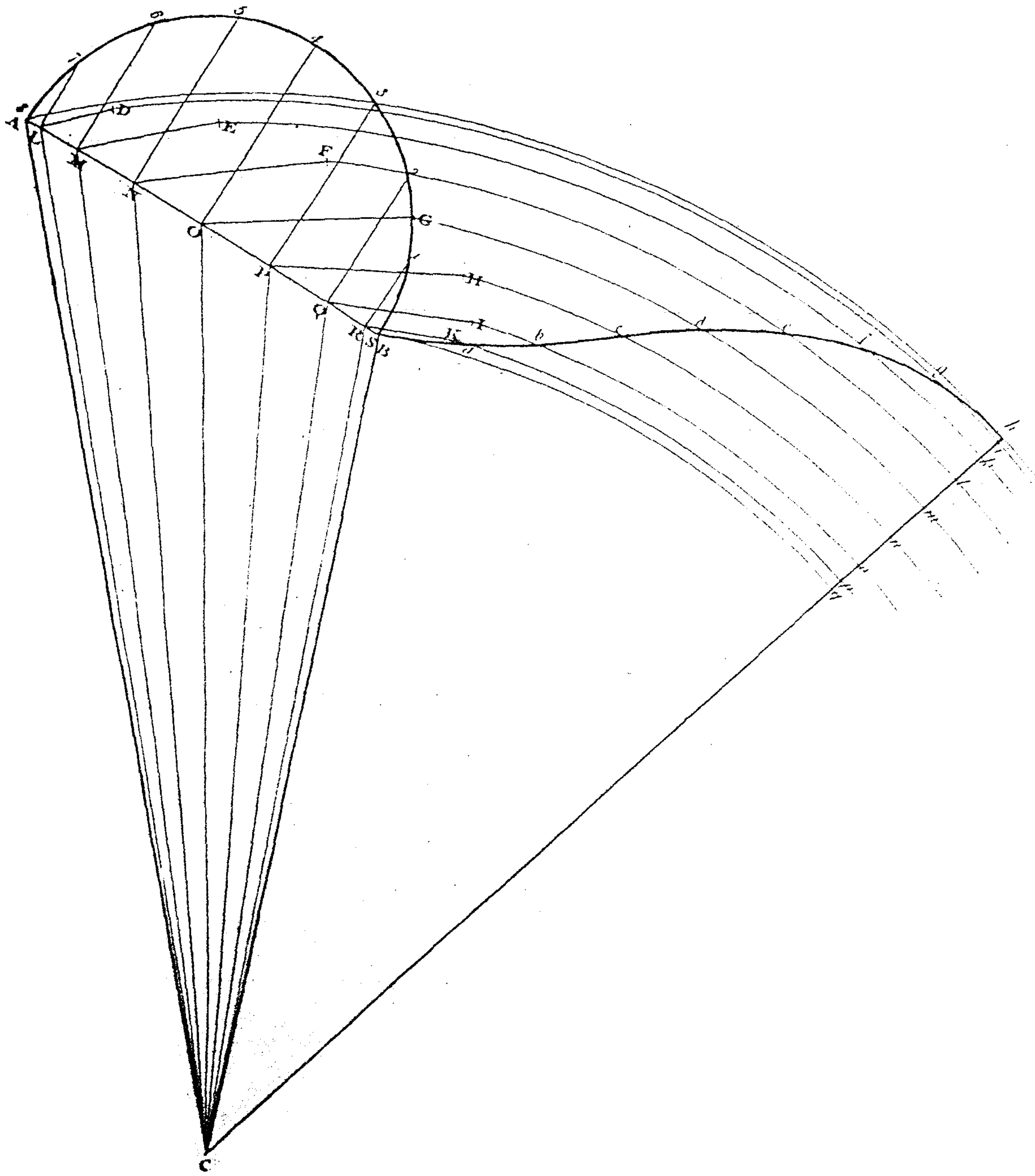
P. S. I beg leave here to obſerve, as the information may have its uſes, that upon enquiry I find the domical roof in my Carpenter's Guide, Plate 48, to be nearly alike in conſtruction with the roof of the dome of the Pantheon, in Oxford-ſtreet, as originally executed by Mr. JAMES WYATT, Architect; alſo, that the roof, Plate 43, of the ſame work, is nearly ſimilar to the one executed by that gentleman, over the ſtage, when the Pantheon was converted into an Opera-houſe.

CONTENTS.

NICHES

STAIR-

Soffit



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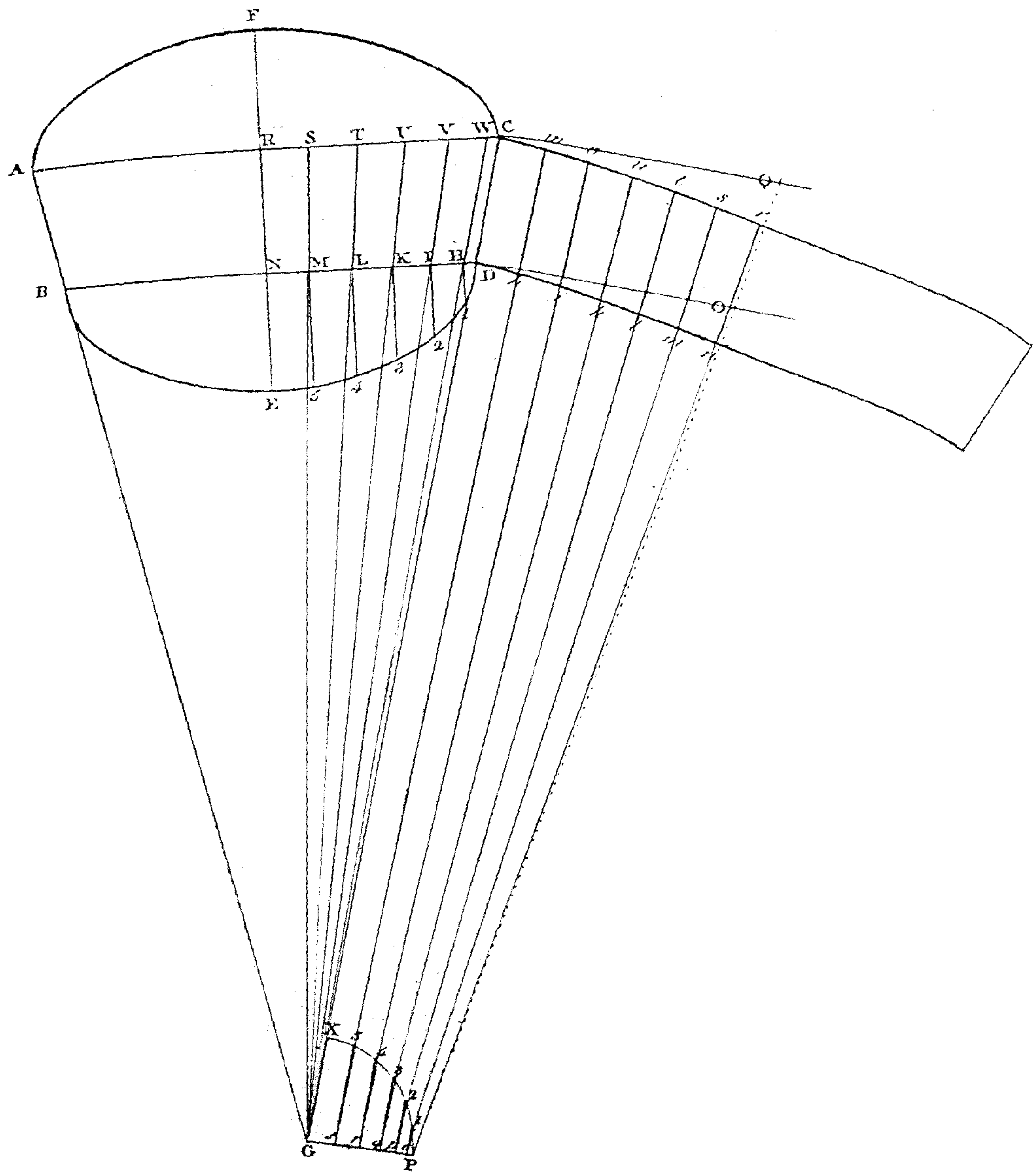
Soffit



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THE

CARPENTER AND JOINER's ASSISTANT.

EXPLANATIONS, &c.

PLATE I.

SOFFITS.

To draw the covering of an oblique cone.

LET *A B C* be the most oblique section of the cone through its axis, and B 1 2 3 4 5, &c. be the base for half the cone, divide it into any number of equal parts at the points 1 2 3 4, &c. through these points draw, 1 *R*, 2 *Q*, 3 *P*, 4 *O*, &c.; perpendicular to *A B* join *C R*, *C Q*, *C P*, *C O*, &c.; then draw *R K*, *Q I*, *P H*, *O G*, &c. respectively perpendicular to *C R*, *Q*, *C P*, *C O*, &c. and respectively equal to *R* 1, *Q* 2, *P* 3, *O* 4, &c. through the points *B*, *K*, *I*, *H*, *G*, *F*, &c. describe the arc *s*, *B* 9, *K p*, to *H n*, *G m*, &c. Then take any of the equal parts, as from *B* to 1, or from 1 to 2, round the semicircle; put one foot of the compass in *B* cross the next arc at *a*, then put one foot in *a* cross the next in *b*, then put one foot in *b* cross the next in *c*; and in this manner proceed through all the points, till you arrive at *h* the last point; then will *B a b c d e f g h C* be the edge of the covering of the half cone.

PLATE II.

SOFFITS.

How to draw a soffit fluing from the plan and level at the crown when both the outside and inside arches are elliptical.

Let *A B D C* be the plan of a door or window having a soffit of this nature, and let *A F C*, *B E D*, be the outside and inside arches, divide half of the arch *D E B*, as *D* 1 2 3 4 5 *E* into any number of equal parts, as six, and produce *A B* and *C D*, the

two

two ſides of the plan, till they meet in *G*; from the points *C*, *D* and *G*, draw the lines *C Q*, *D O*, and *G P*, perpendicular to *C G*; make *D O* and *C Q* reſpectively equal to the arc, *D E* and *C F*; through the points *Q* and *O* draw the line *Q O P*, cutting *G P* in *P* on *G*; with the radius *G P* deſcribe the quadrant *P X*, divide the arc *P X* into as many equal parts as the arc *D E* is divided into at; 1, 2, 3, 4, 5, draw lines 5 *s*, 4 *r*, 3 *q*, &c. parallel to *X G*, cutting *G P* at *s*, *r*, *q*, *p*, and *o*, take the diſtance *G H*, from *s* deſcribe an arc at *h*, take the diſtance between *D* 1 or 1 and 2 on the arc *D E*, then on *D* croſs the former arc at *h*, then take *G I*, on *r*, deſcribe an arc at *i*, then with the ſame diſtance as before, viz. between *D* 1 or 1 and 2, on *h* deſcribe an arc cutting the former at *i*; then take *G K*, and on *q* deſcribe an arc at *k*; then again, with the diſtance D 1 on *i*, croſs the arc *k* at *k*. Proceed in this manner to find the points *l*, *m*, and *n*, then will the points *D*, *h*, *i*, *k*, *l*, *m*, and *n*, coincide reſpectively on the arch at *D* 1, 2, 3, 4, 5, and *E*, which will give one half of the curve for the arch *D E F*, the points *C*, *w*, *v*, *u*, *t*, *s*, *r*, to cover the arch *C F A* will be found by making *h w*, *i v*, *k u*, *l t*, *m s*, and *n r*, equal to their correſponding diſtance *H W*, *I V*, *K U*, *L T*, *M S*, and *N R*; a curve being traced through theſe points will give one half of the ſoffit, from this a mould may be made that will give the other half.

PLATE III.

GROINS.

How to draw and fix the ribs of a plaiſter groin whoſe plan is rectangular and the arches to interſect each other at their common height.

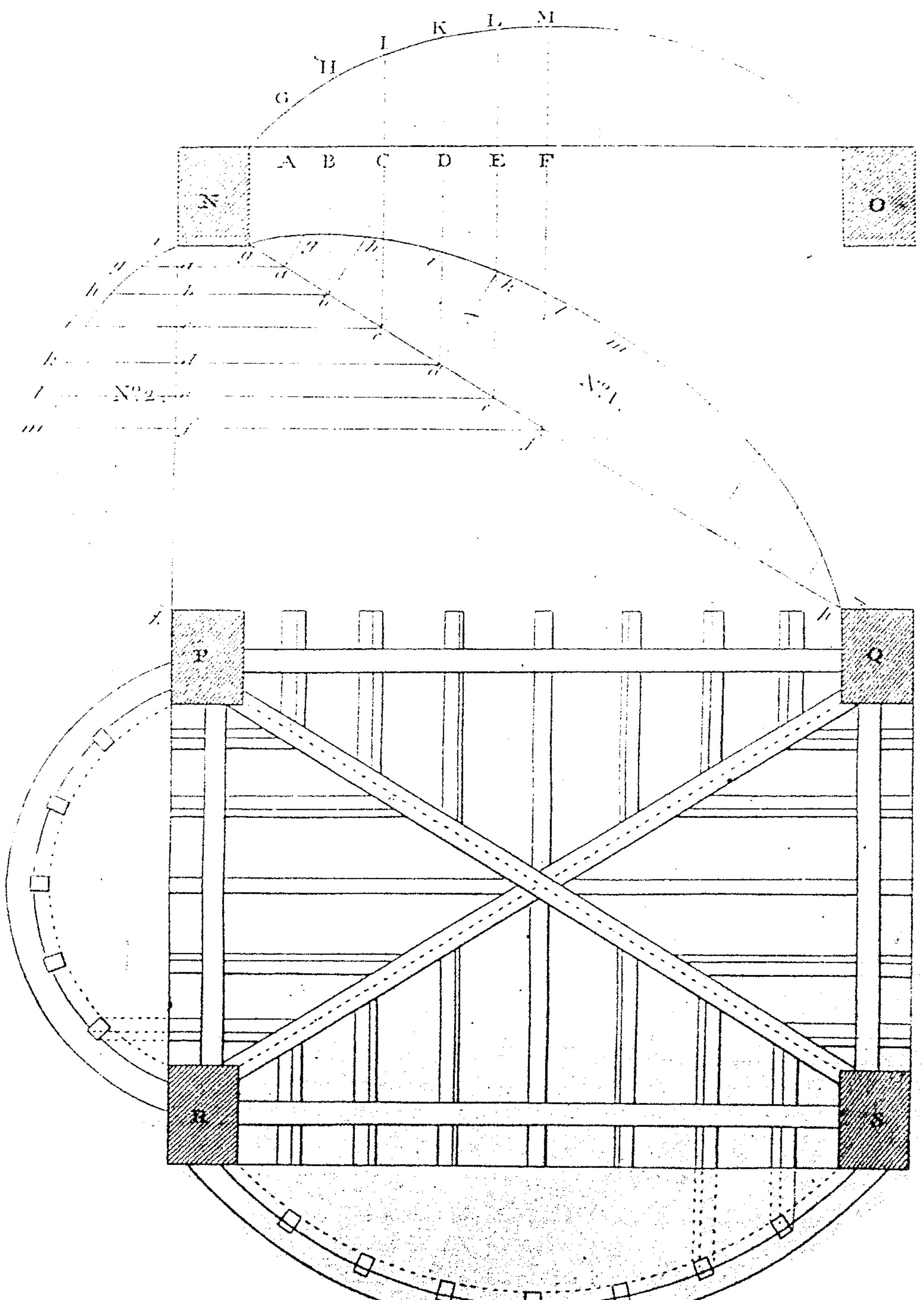
Let *G H I K L M* be one of the arches given, ſtanding over *A B C D E F* on the plan, or in any other poſition parallel to it; let *N*, *O*, *P*, *Q*, *R*, *S*, be the piers on which the ribs are to ſtand.

Take any points *G*, *H*, *I*, *K*, *L*, and *M*, at pleaſure, from theſe points draw lines *M F f*, *L E e*, *K D d*, *I C c*, &c. perpendicular to the baſe *A B C D E F*, cutting the angular rib *g h* at the joints *a*, *b*, *c*, *d*, *e*, *f*; from theſe points draw perpendiculars *a g*, *b h*, *c i*, *d k*, *e l*, and *f m*, to *g h*; alſo through the points *a*, *b*, *c*, *d*, and *e*, in *g h* No. 1, draw parallel lines to the other ſide of the groin *a a g*, *b b h*, *c c i*, *d d k*, *e e l*, and *f f m*, cutting *i k* at the points *a*, *b*, *c*, *d*, *e*, and *f*; then make all the diſtances *a g*, *b h*, *c i*, *d k*, *e l*, *f m*, in No. 1, and No. 2, equal to correſponding diſtances, *A G*, *B H*, *C I*, *D K*, *E L*, and *F M*, will be points in half of the arches at No. 1 and No. 2, from which the curve of the rib may be completed.

The fixing of the ribs of the groin may be as follows:

Put principal ribs acroſs the piers each way, alſo acroſs the diagonals; then put ſtraight ribs acroſs theſe parallel to each ſide of the groin, meeting on the diagonal rib in order to fix the laths.

PLATE



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Groins

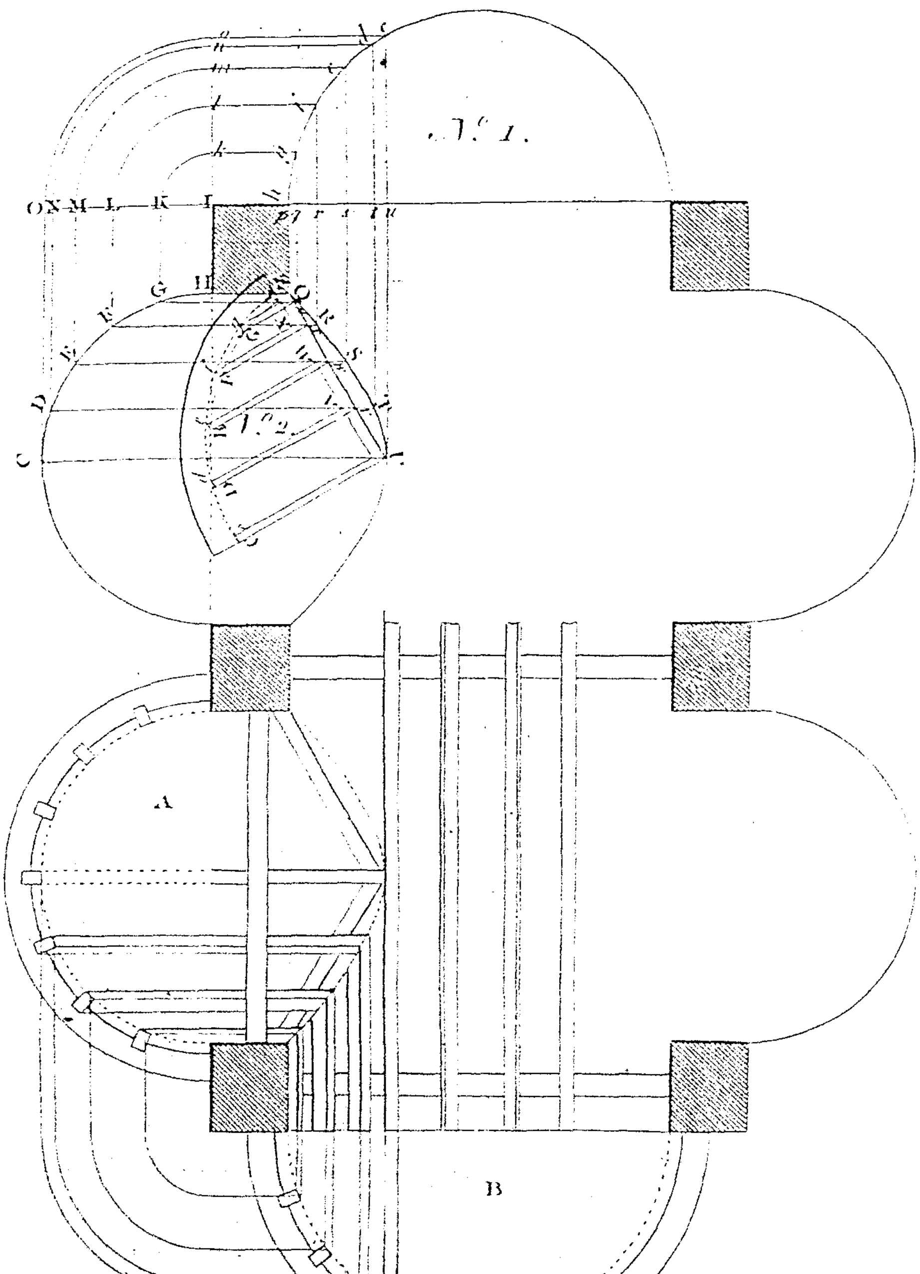

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PLATE IV.

GROINS.

How to draw and fix the ribs of a Welsh groin by an easy method.

In order to have a correct idea of the manner of finding the lines of this groin, it will first be necessary to know the manner in which the ribs are to be fixed.

The rib over *B* is one of the body range, the rib at *A* is one of the side arches cutting under the former; the principal ribs are first fixed across the piers, then straight ribs may be notched across the under edge of the principal ones, so as to meet each other exactly at the intersection of the two sides of the groin.

How to describe an angle rib for this groin.

Divide the half arch *C D E F G H* into any number of parts at the points *D*, *E*, *F*, *G*, through these points draw the parallel lines *C O*, *D N*, *E M*, *F L*, &c. parallel to the body range of the groin cutting the other side of the groin produced, at *O*, *N*, *M*, *L*, *K*; then on *I* as a centre, with the distances *I K*, *I L*, *I M*, *I N*, and *I O*, as radii, describe the quadrants *O o*, *N n*, *M m*, *L l*, and *K k*, cutting the side of the groin produced at *o*, *n*, *m*, *l*, *k*; through these points draw lines *o c*, *n d*, *m e*, *l f*, &c. parallel to *O I*, cutting the body range at *c*, *d*, *e*, *f*, *g*; through these points draw parallels *c U*, *d T*, *e S*, *f R*, &c.; also through the points *C*, *D*, *E*, *F*, *G*, draw the parallels *C U*, *D T*, *E S*, &c. cutting the former at *U*, *T*, *S*, *R*, which will give the seat of the angle.

How to trace and back the angle rib.

From the angle of the pier at *N*, and the middle of the seat of the angle at *U*, join *N U*, cutting the lines *D T*, *E S*, *F R*, and *G Q*, at the points, *v*, *w*, *x*, and *y*; draw the line *z y* parallel to *U Z*, distant from each other the thickness of the rib, cutting *C U*, *D T*, *E S*, *F R*, and *G Q*, at *z*, *V*, *W*, *X*, *Y*; through the points *U*, *u*, *v*, *V*, *w*, *W*, *x*, *X*, *y*, *Y*, draw the perpendiculars *U C*, *u c*, *v D*, *V D*, *w E*, *W e*, *x F*, *X F*; make *u c*, *V d*, *W e*, *X f*, and *Y g*, on No. 2, respectively equal to *u c*, *t d*, *s e*, *r f*, and *q g*, and through the points *c*, *d*, *e*, *f*, *g*, *m*, No. 2, draw *C c*, *D d*, *E e*, *F f*, *G g*, parallel to *U Z*, cutting *U C*, *T D*, *S E*, &c. at *D*, *E*, *F*, and *g*; then will *C D E F G* be one of the backing lines, and *c d e f g* the other.

PLATE V.

ARCHES FOR MASONRY.

To find out the points of an elliptical stone arch cutting oblique in a straight wall.

Divide half of the arch *B C* perpendicular to *A F*, *fig.* 1. into any odd number of equal parts, two of which parts are supposed equal to the thickness of one of the stones on the under side of the arch; this is done so that there may be a stone in the middle of the arch, instead of a joint. Then the distances between 1, 2, 3, 4, 5, &c. contain each two parts. Find one half of the soffit at *fig.* 3, as is shown in the *Carpenter's New Guide*, *fig. A.* plate 2. Then will 1, 2, 3, &c., in *fig.* 3, be the moulds for the underside of the stones, at 1, 2, 3, &c. in *fig.* 1; the widths of the moulds at No. 1, No. 2, No. 3, &c. are respectively equal to *C L*, 1 *a*, 2 *b*, 3 *c*, &c. in *fig.* 1. Then the rhomboides *E*, *M*, *G*, *L*, will be a mould for the joint *C L*, it will be enough to describe any one of the joints. Suppose 7 *g* at *fig.* 1, draw *g e* perpendicular to *A C*, cutting *D E*, at *e*, and 7, 5 *m*, parallel to it; from *e*, draw *e* 5 perpendicular to *g e*, then take the distance 5 *m*, in *fig.* 1, and set it from 7 to *m*, at No. 7, draw 7 *g* perpendicular to it, equal to 7 *g* at No. 1, join *m g* in No. 7, continue *m* 7 to *h*, make *m h*, at No. 7, equal to *E M*, at *fig.* 1, then complete the parallelogram, *m g i h*, will be a mould for the joint 7 *g*, at No. 1.

PLATE VI.

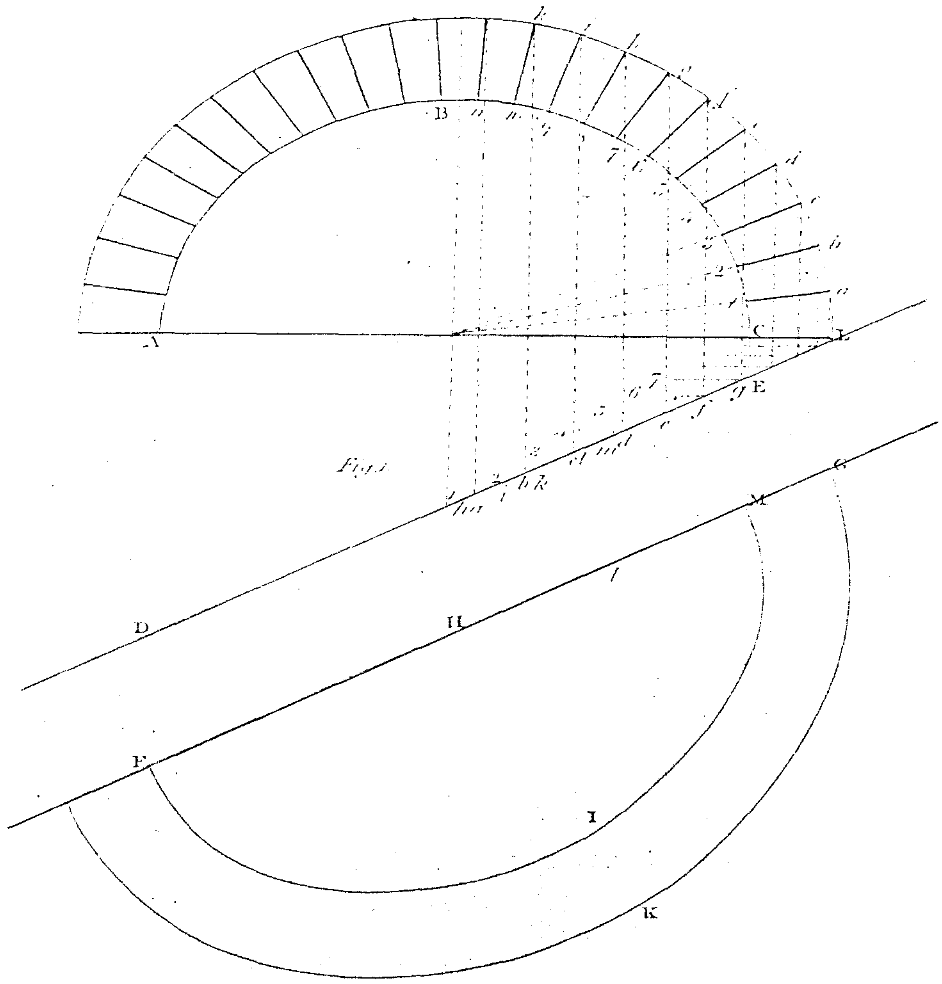
ARCHES FOR MASONRY.

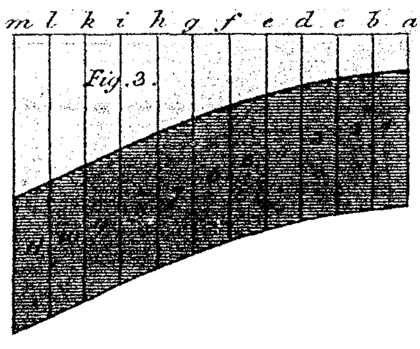
In plate 5. has already been shewn the method for finding the lines of an elliptical arch, cutting obliquely into a straight wall, by a general method which may be applied to circular walls; but in this I shall shew a more particular rule which will be shorter in practice for this kind of arch.

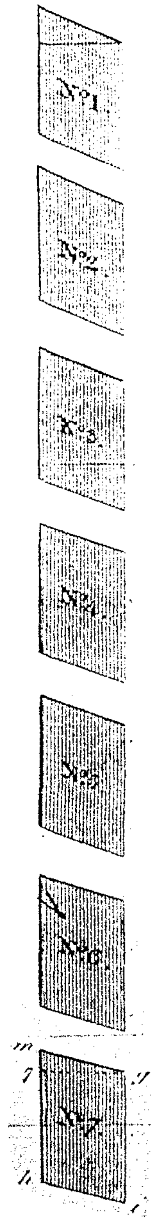
First find the soffit as in *fig.* 2, for the underside of the arch; now in order to find the levels of the side joints, at *B*, *C*, *D*, *E*, *F*, *G*, &c. draw parallels *B Q*, *C R*, *D S*, *E T*, &c. cutting the face of the wall at *Q*, *R*, *S*, *T*, &c.; from these points draw the perpendiculars *Q q*, *R r*, *S s*, *T t*, &c. to the lines *B Q*, *C R*, &c.; take *O b*, on *P*, cross the perpendicular *Q q*, at *q*, draw *p q*, then take *o c*, on *P*, cross *R r* at *r*, and join *P r*; take *o d* on *P*, cross *S s* at *s*, join *P s*; in this manner proceed to find all the other lines *P t*, *P u*, *P v*, *P w*, &c. then will *P q*, *P r*, *P s*, &c. make angles with the line *O P*, which the end of each joint must make with the underside respectively at the joints *B*, *C*, *D*, *E*, *F*, &c.

PLATE

Arch for Masonry.







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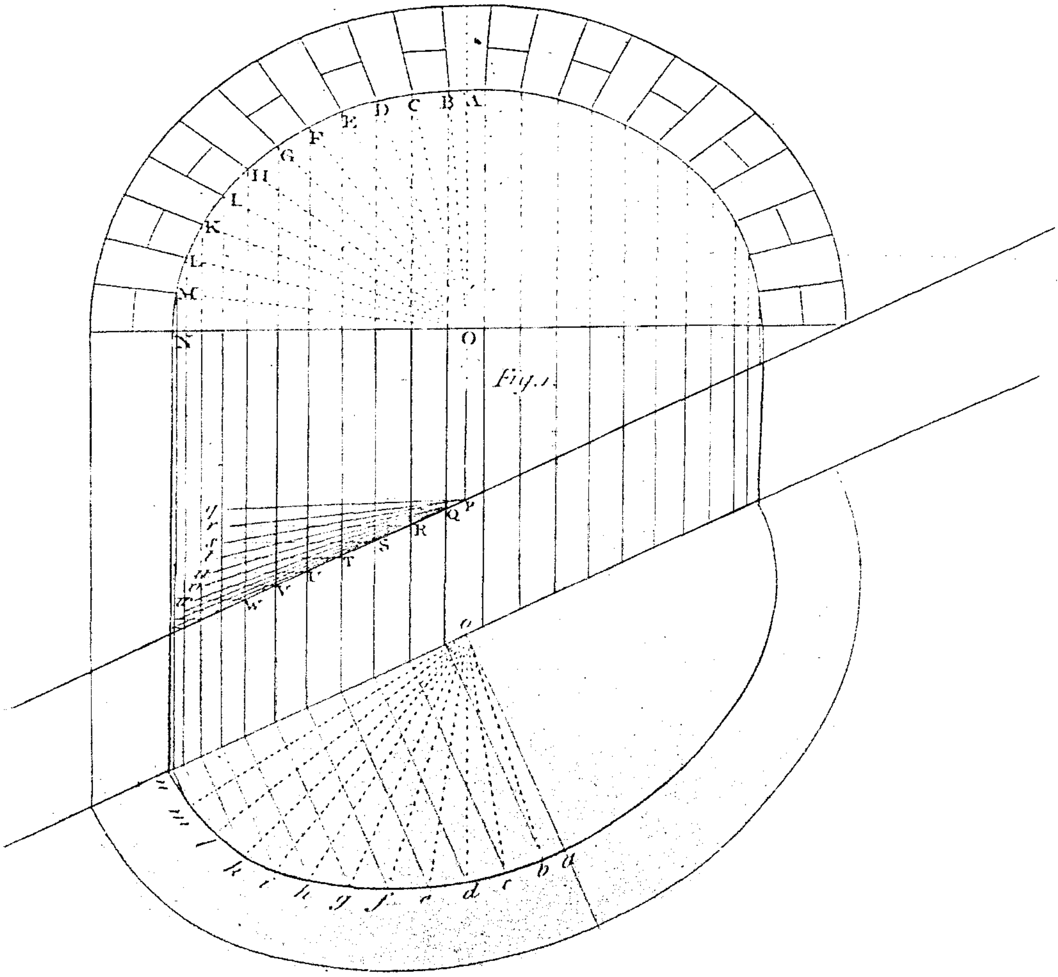

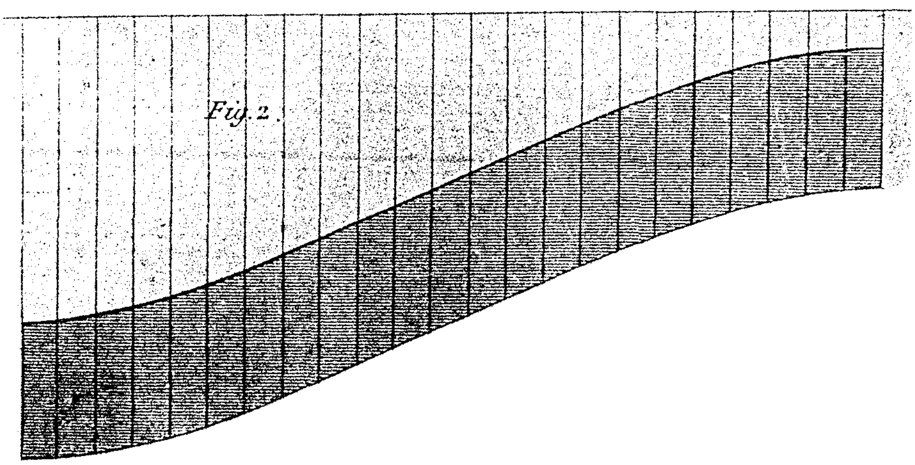

Fig. 2.

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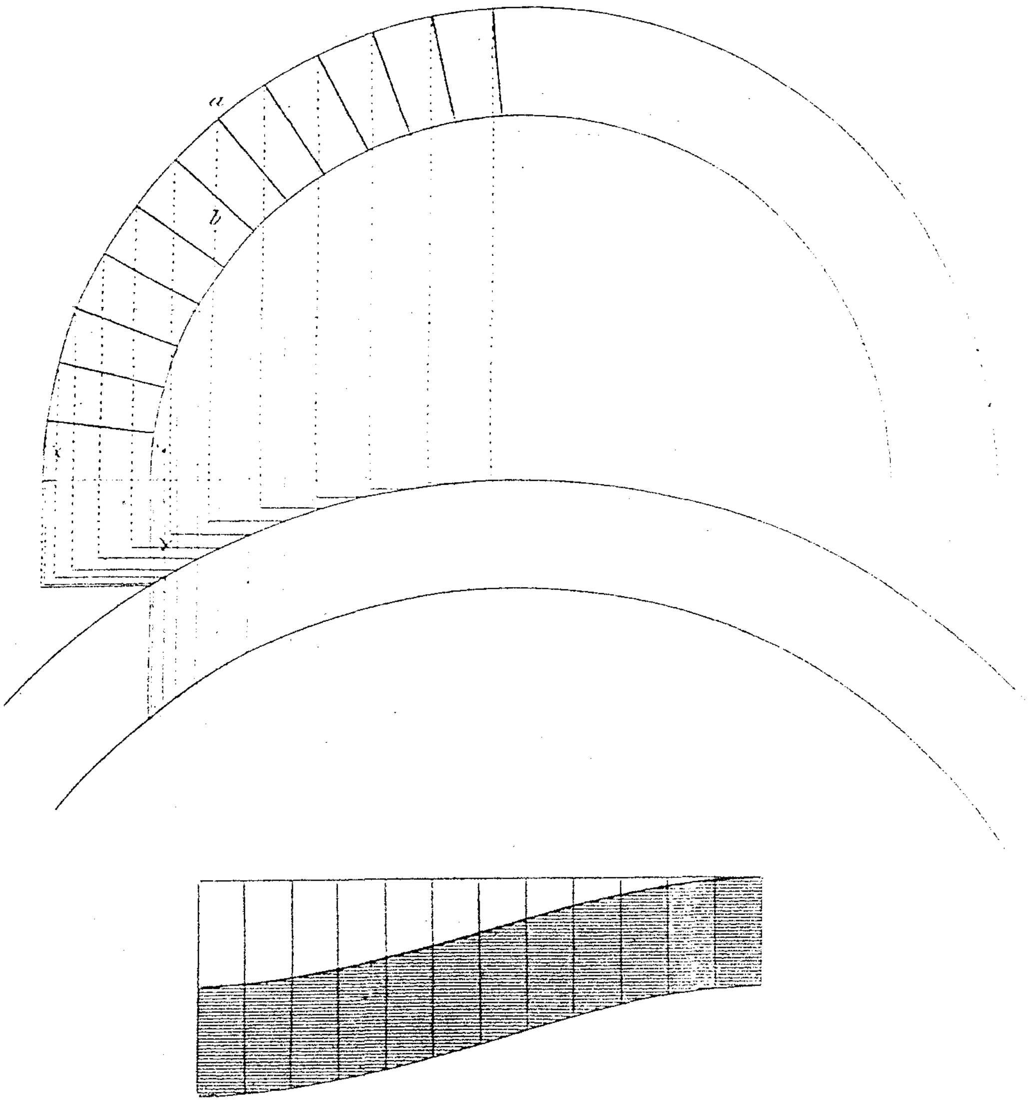

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Fig. 2.

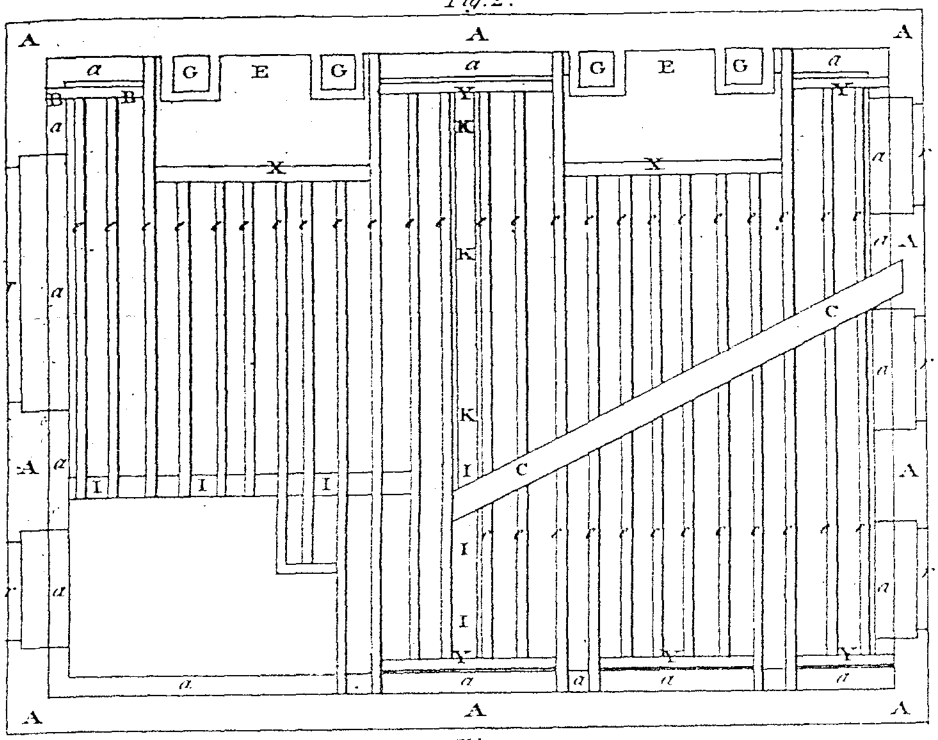

Fig. 1.

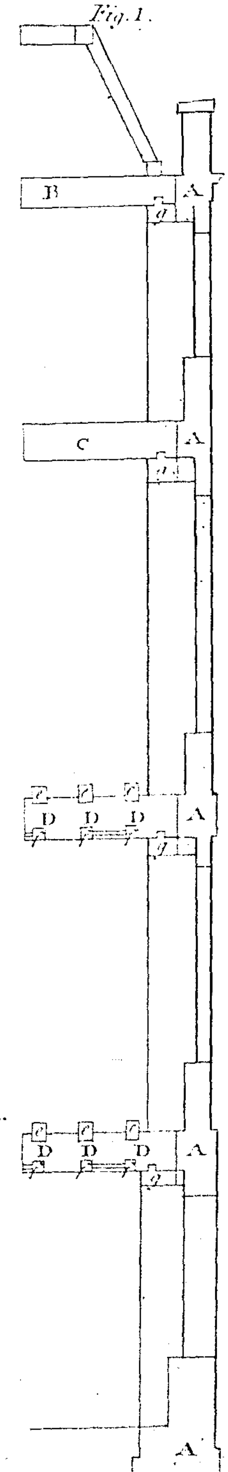

Fig. 3.

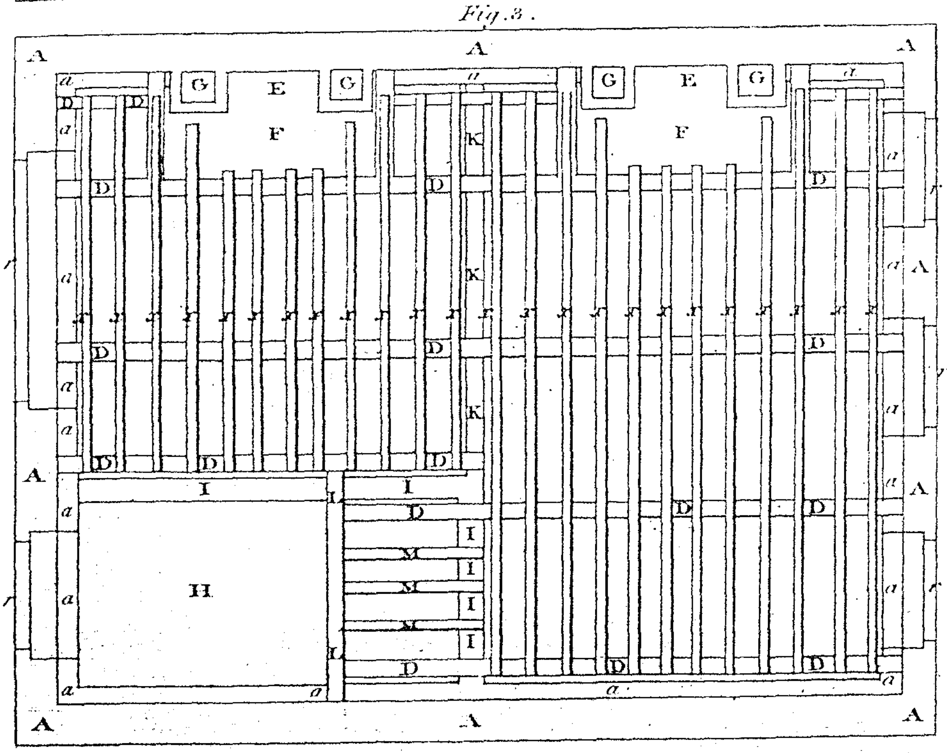

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PLATE VII.

ARCHES FOR MASONRY.

Of a ſtone arch in a circular wall.

The deſcription of this arch is ſimilar to that of the elliptical arch, cutting obliquely into a ſtraight wall, as has already been deſcribed in plate 5. That is, the moulds for the underſide of the ſtones and the joints will be found, as in that plate; but the fronts of the ſtones muſt be wrought circular to the plan, or perpendicular, on the elevation; therefore in order to bring the face of each ſtone, forming the arch, to the true curve of the wall, a ſtraight edge applied to the face of each ſtone, which muſt be in a direction which would be perpendicular when put in its place, which line may be found as follows: from the elevation draw a perpendicular line *a b*, cutting the top of the joint of the ſtone at *a*, and the ſide at *b*, then the ſtone being wrought on four ſides, the face will be eaſily wrought by keeping the ſtraight edge always parallel to *a b*.

PLATE VIII.

OF FLOORS.

FIG. 1, the perpendicular ſection of a houſe through the windows.
A A A A A, ſection of the walls through the windows.
B, tie beam.
g g g g, &c. the wall plates, on which reſts the tie beams, girders and binding joiſts.
C, a girder cocked down to the wall plate *g*.
D D D, binding joiſts in the floors.
e, *e*, *e*, are the ends of the bridging joiſts, running over the binding joiſts.
f, *f*, *f*, the ends of the cieling joiſts which are chaſed at one end in the binding joiſts.

FIG. 2. *The plan of a floor with a girder, ſhewing how to place the ſame.*

No girder, or ſtrong tie, ſhould be placed over any opening, and as the beſt method of laying girders, is to have them exactly in the middle of the room and parallel to the walls on each ſide; but as this is not always practicable, as in the preſent example, there being an opening, or window, in the middle of the room; therefore, that the girder may divide the

the room, as near as poſſible, into two equal parts, let the one end of the girder reſt upon the pier that is neareſt to the middle, and the other at the ſame diſtance on the contrary ſide in the oppoſite wall.

A A A A, &c. plan of the walls.

G G G G, the flues.

r, *r*, *r*, *r*, *r*, thickneſs of the brick work, from the outſide of the ſaſh frame to the outſide of the wall.

a, *a*, *a*, *a*, *a*, &c. plan of the wall plates.

C, *C*, the girder.

e, *e*, *e*, *e*, *e*, &c. the joiſts framed into the girder *C* and into the tail-trimmers *Y*, *Y*, *Y*, &c.

Y, *Y*, *Y*, *Y*, &c. tail-trimmers, in order to prevent the ends of the timbers, as much as poſſible, from going into the wall; according to the regulations of the building act.

X, *X*, hearth trimmers.

K, *K*, *K*, a ſix inch partition between the rooms.

I I I I I I, a nine inch wall encloſing the ſtairs.

FIG. 3. *Plan of a double floor.*

In this the ſame letters refer to the ſame things as in *fig.* 2.

D D D, *D D D*, *D D D*, &c. binding joiſts, their ſides are ſhewn at *D D D*, in *fig.* 1.

x, *x*, *x*, *x*, &c. bridging joiſts.

L L, the ſtair-trimmer.

M, *M*, *M*, ſingle joiſts framed into the ſtair trimmer, *L L*.

PLATE IX.

OF FLOORS.

No. 1. *Plan and two elevations, with ſections, of naked flooring and walls, ſhewing how to conſtruct the bond timbers in the wall, alſo the manner of framing the floors for ſmall buildings, or buildings of the third or fourth claſs.*

Plan of the flooring.

BBBBBB, plan, or a horizontal ſection of the brick work.

C, *C*, windows.

D, chimney.

E, flue.

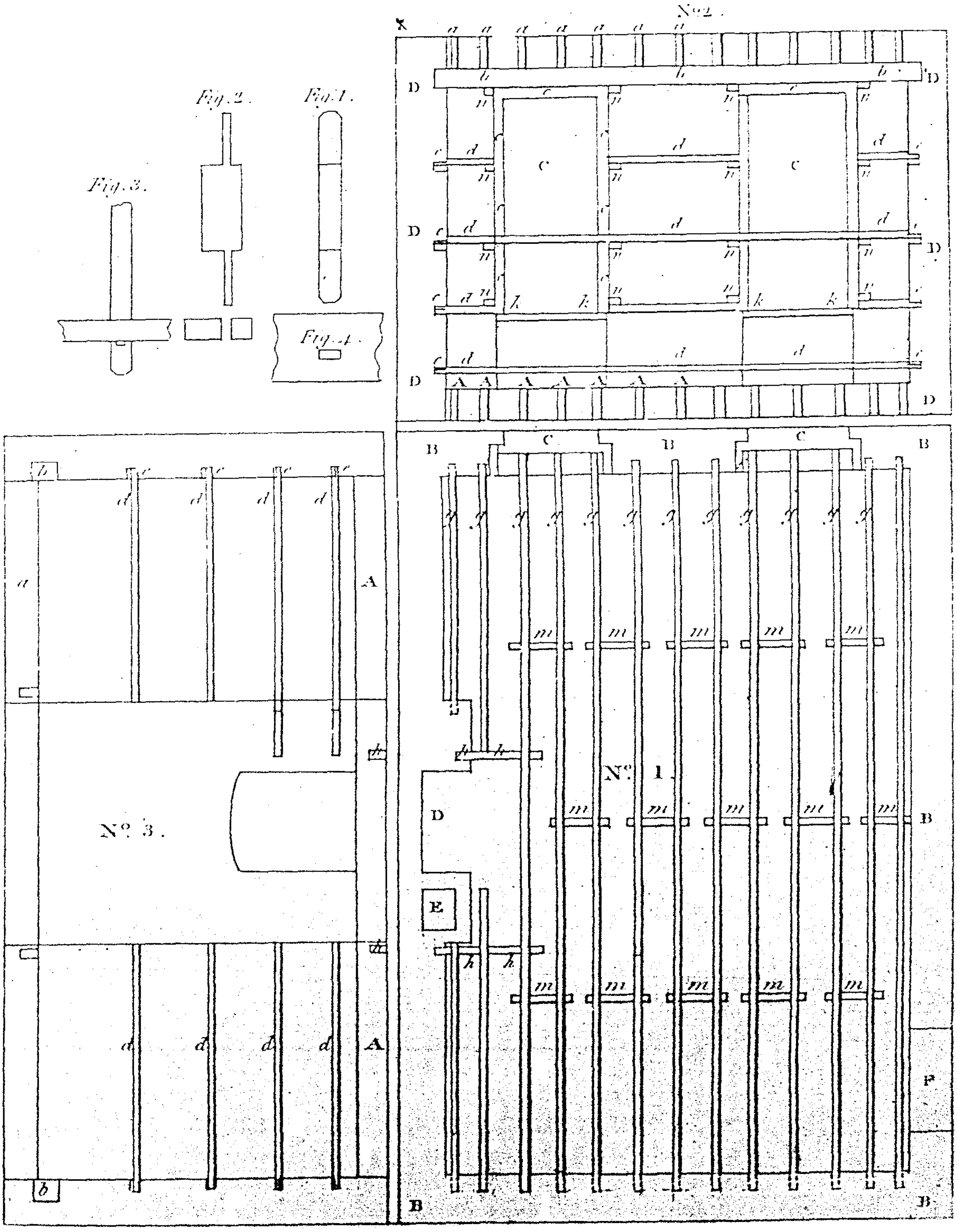
F, door.

g g g g, &c. common joiſts.

h h h h, trimmer joiſts framed into the common joiſts.

m m m m, &c. keys to ſtrengthen the joiſts. *Fig.* 1. ſhews the edge or top of a key. *Fig.* 2. the ſide of ditto. *Fig.* 3. a key framed into the joiſt. *Fig.* 4. ſide view of a joiſt, ſhewing the mortiſe to receive the key.

No.



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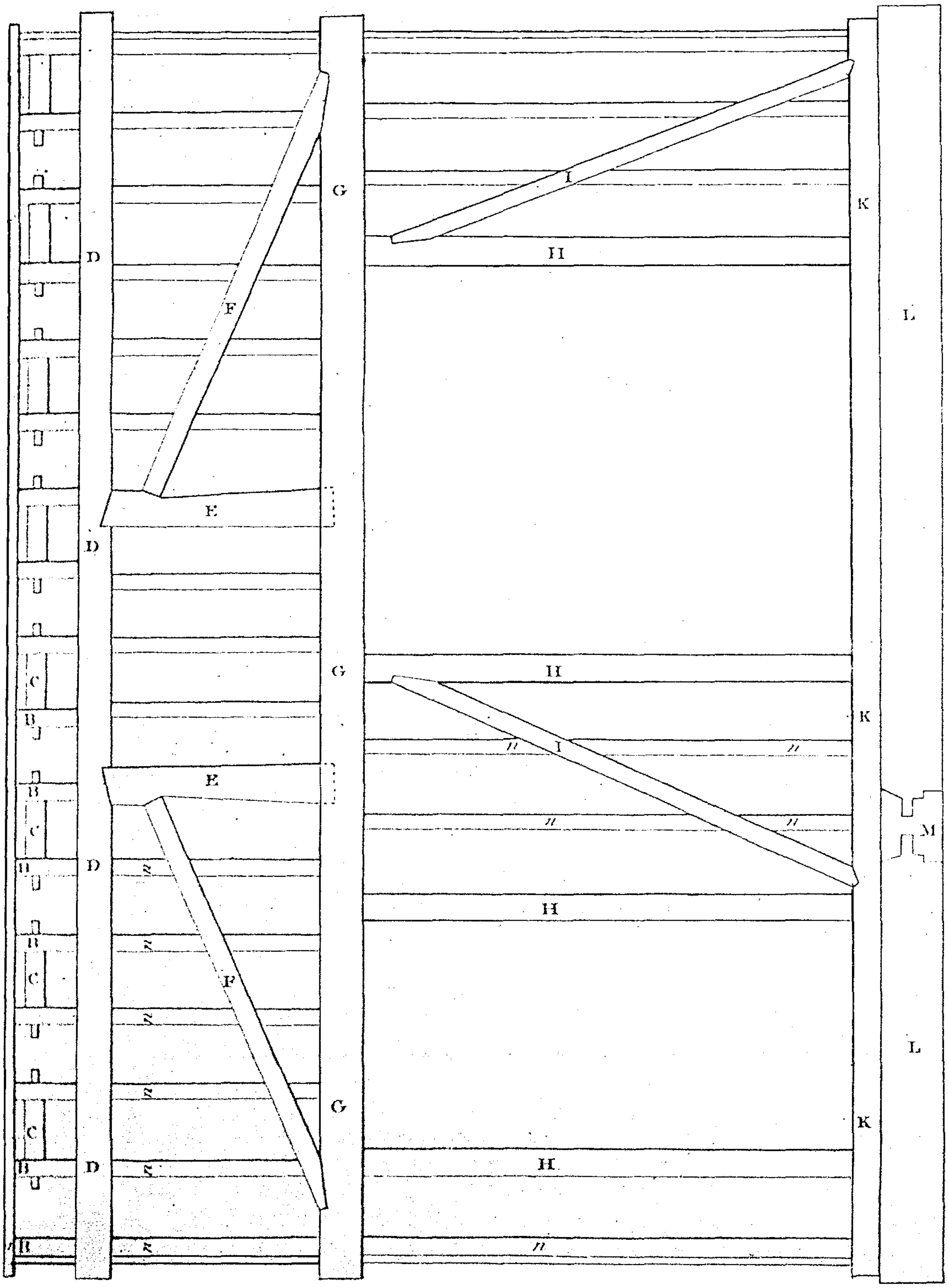
Trussed Partition.



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No. 2. *Elevation of the window ſide of the room.*

C, *C*, windows.
c c c c, &c. the breadth of the receſſed part of the window.
k k, bond timbers under the window.
a a a a, &c. the ends of the joiſts of the floor above the windows.
b b b, a wall plate for the joiſts.
d d d and *d d d*, bond timbers in the wall.
e, *e*, *e*, *e*, &c. the ends of the bond timber in the ſide walls.
n, *n*, *n*, *n*, &c. the ends of the bond timber from the receſs of the windows.
A A A A, the joiſts of the floor, below the window.

No. 3. *Elevation of the chimney ſide of the room.*

The letters of reference are the ſame as to No. 2.

PLATE X.

TRUSSED PARTITIONS.

Deſign for a truſſed partition, with door-ways in it.

B, *B*, *B*, *B*, *B*, &c. the ends of the joiſts of the floor, above the partition.
C, *C*, *C*, *C*, keys put between the ſteady joiſts, when they have a long bearing, and to ſtrengthen the floor.
a a a a, thickneſs of the floor.
D D D D, top of the partition.
E, *E*, queen poſts.
F, *F*, braces, to keep the building ſteady.
G G G, lintle-piece over the doors.
H, *H*, *H*, door poſts.
I, *I*, braces for the lower partition.
K K K, bottom of the partition.
L, *L*, joiſts going into the girder *M*.
M, the girder ſhewing the tenons.
n, *n*, *n*, *n*, &c. are upright quarterings.

PLATE

PLATE XI.

OF ROOFS.

The width of a roof being given, and the quantity of timber to make it, to find the height ſo that it ſhall be the ſtrongeſt poſſible.

FIG. 1. Let *A B* be the width, or ſpan, between the principal rafters: on it deſcribe a ſemicircle, *A d e B*; divide *A B* into three equal parts at the points *a* and *b*; from theſe points draw the perpendiculars *a d* and *b e*, cutting the circle in *d* and *e*, join *A e* and *d B*, cutting each other at the point *C*; then will *C A* and *C B*, be the upper edge of the principal rafters, wich will alſo conſtitute the height of the roof.

FIG. 2. is a deſign for another roof, made on the ſame conſtruction, for a ſmaller ſpan.

Names of the timbers.

A B, the tie beam.

C L, the king poſt mortiſed and bolted into the tie beam at *L*. See alſo No 1.

I I, braces mortiſed into the king poſt.

A C and *C B*, are principal rafters mortiſed into the tie beam, at *A* and *B*, (ſee No. 6.) and into the king poſt at *C*, and alſo into the braces.

G, *G*, ſections of the wall plates, which are let into the tie beam in order to bind the walls of the building together. (See No. 5, 6.)

F, *F*, pole plates.

K, *K*, ſections of the purlines.

m, ridge tree.

H H, and *h h*, common rafters ſupported at the bottom by the pole plates *F*, *F*, in the middle by the purlines, *K*, *K*, and at the top by the ridge tree, *m*.

No. 1, the king poſt, and tie beam to a larger ſcale.

No. 2, upper ſide of the tie beam ſhewing the mortiſe.

No. 3, wall plate, ſhewing how it is made to receive the tie beam.

No. 4, underſide of the tie beam.

No. 5, and 6, end of the roof to a larger ſcale.

PLATE

Fig. 1.

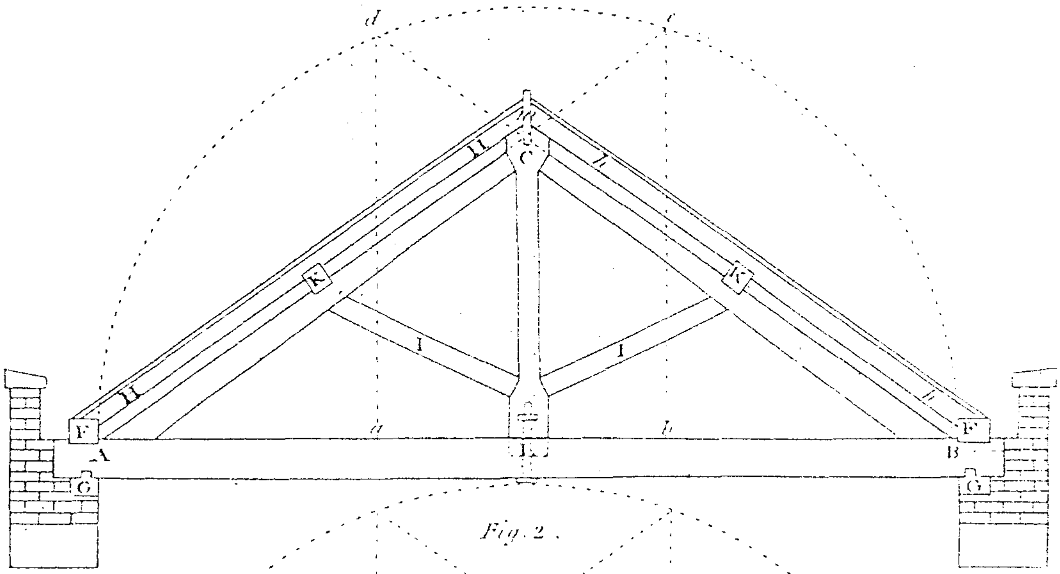
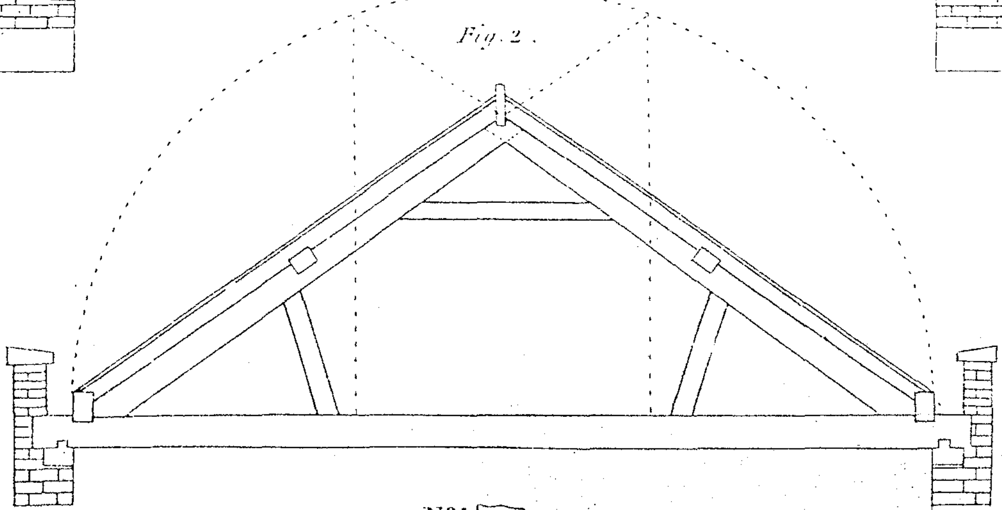
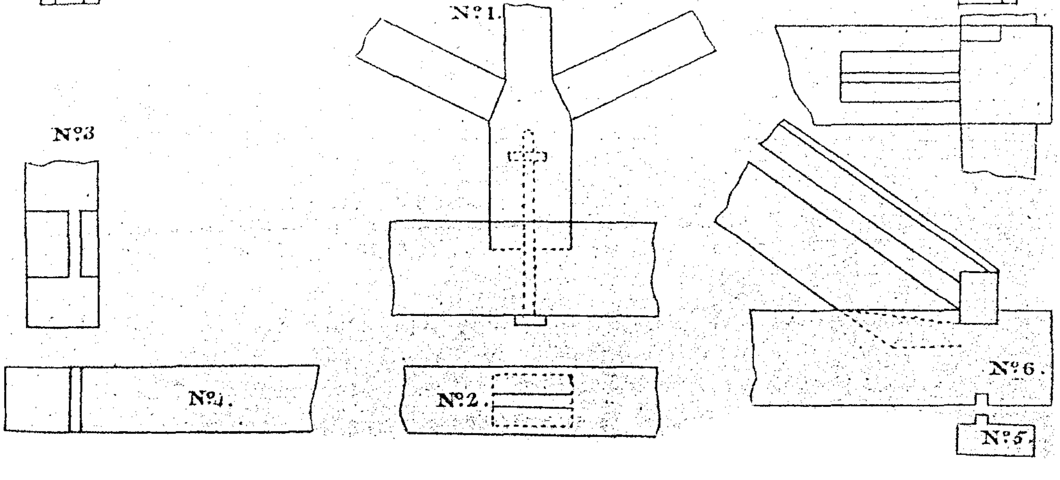


Fig. 2.





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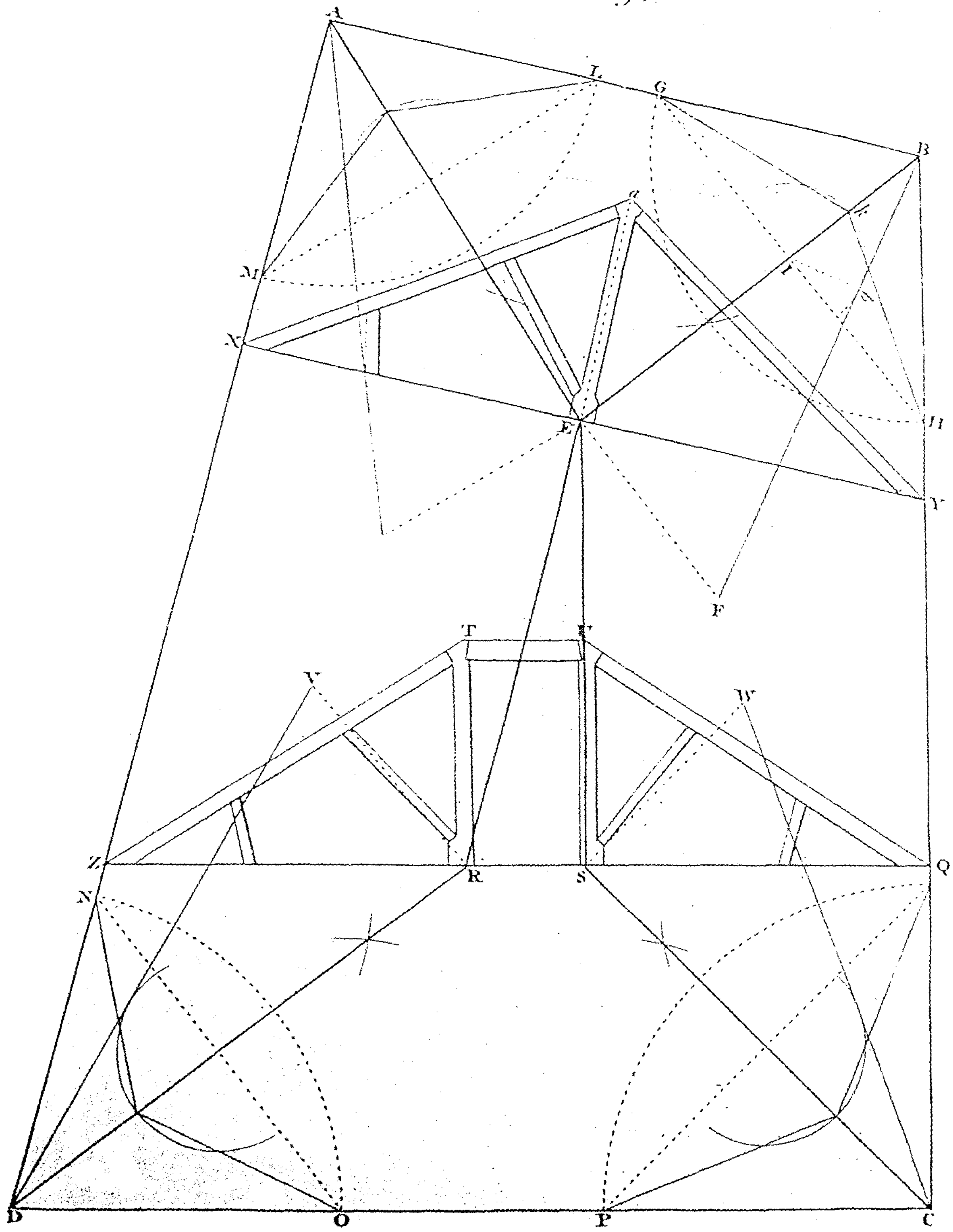

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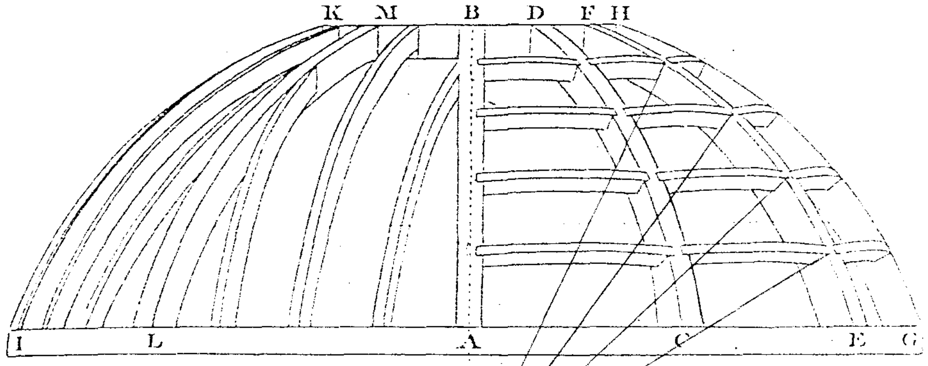
Fig. 1.



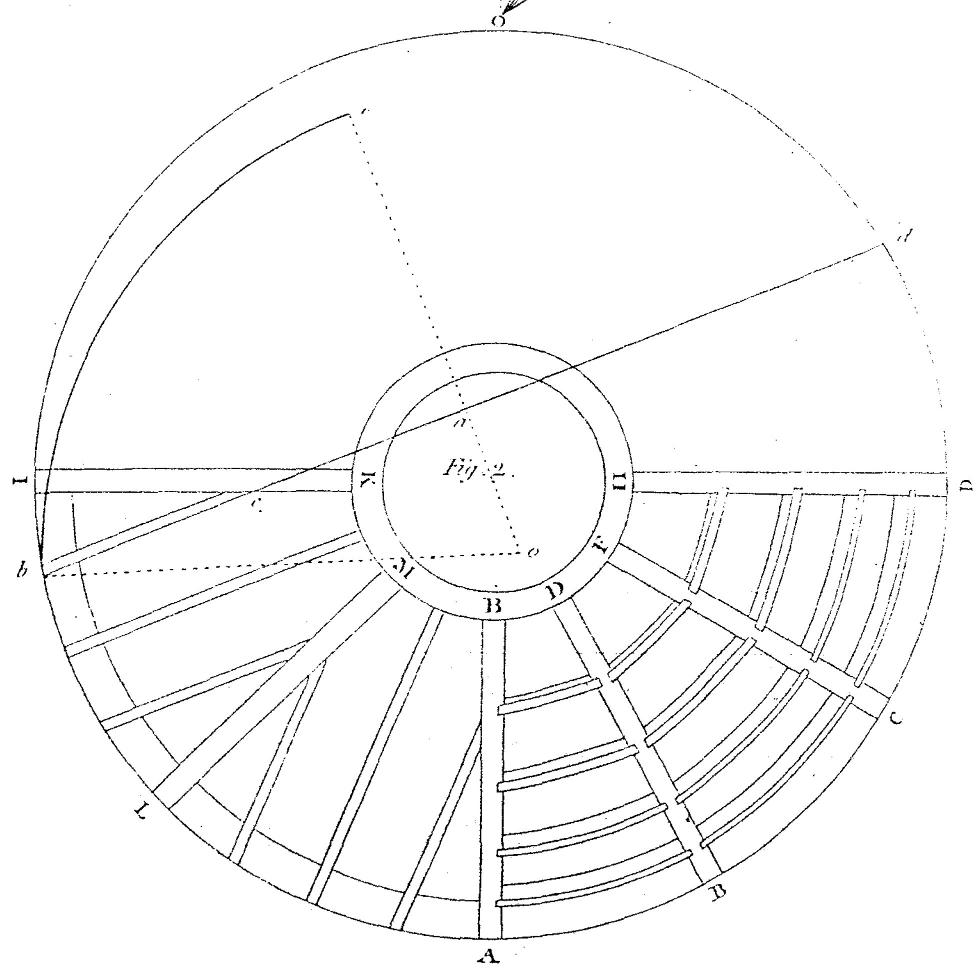


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PLATE XII.

ROOFS.

To make a roof when the plan is of the form of a trapezium.

Let $A\,B\,C\,D$ be the plan, bisect all the angles $L\,A\,M$, $G\,B\,H$, $Q\,C\,P$ and $O\,D\,N$, respectively, by the right lines $A\,E$, $B\,E$, $C\,S$, and $D\,R$, which will give the seat, or plan, of the hips. Through E, the intersection of the lines $A\,E$ and $B\,E$, draw $X\,Y$ parallel to $A\,B$, cutting the sides of the plan in X, and Y; from E, draw $E\,a$ perpendicular to $X\,Y$, equal to the intended height of the roof; draw $a\,X$ and $a\,Y$, which will give the hip rafters to stand over $X\,Y$; also through E, draw $E\,R$, and $E\,S$, respectively parallel to $A\,D$, and $B\,C$, the plan of the roof cutting the plan of the hips $D\,R$ and $C\,S$, at R and S, through R and S; draw $Z\,R\,S\,Q$ cutting $A\,D$, and $B\,C$, at Z and Q, then will $E\,R\,S$ be a flat on the top.

To find the hip rafters.

From E draw $E\,F$, perpendicular to $B\,E$, equal to $E\,a$; join $B\,F$, and $B\,F$ will be the length of a hip rafter, to stand over $E\,B$, on the plan.

To find the angle at the back of the hip rafters.

Draw any line $G\,H$, perpendicular to $B\,E$, cutting it at I, and the plan at G and H; through I, draw $I\,b$, perpendicular to $B\,F$, cutting $B\,F$ in b; make $I\,k$ equal to $I\,b$, join $G\,k$ and $k\,H$; then will $G\,k\,H$ be the angle sought.

PLATE XIII.

ROOFS.

How to fix and describe the ribs in a dome, when the plan is a circle, and the elevation a segment of a circle.

METHOD I.

Fix the principal ribs, as are shown at $A\,B$, $C\,D$, $E\,F$, and $G\,H$, in the elevation and plan, *fig.* 1 and 2; then cut out small notches in their outer edges, in order to receive the cross bars, which cut the principal ribs at right angles, the sides of each bar being in planes,

tending

tending to the centre of the dome: fixing the bars in this manner is extremely eaſy, as all the croſs ribs are of the ſame curve as the principal ribs; theſe croſs ribs being well fixed, by this method it will be as ſtrong as any truſſed dome and much leſs expenſive.

METHOD II.

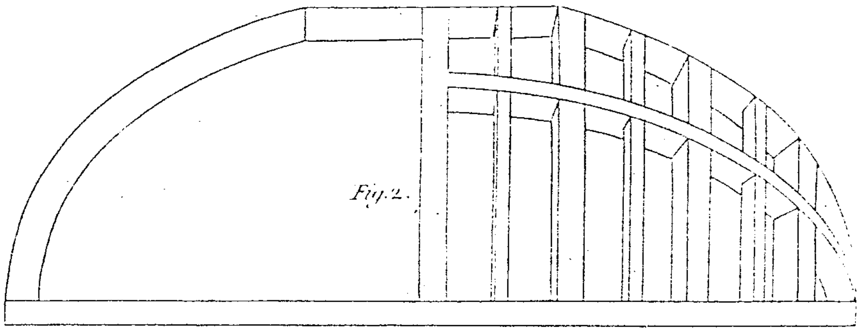
On the other half is ſhown the principal ribs at *I K*, *L M*, and *A B*, at the elevation, *fig.* 1; and on the plan, at *fig.* 2, the principal ribs are filled in between by parallel jack ribs; the manner of finding the centre of them is as follows: ſuppoſe *b c*, on the plan, to be a jack rib; continue it till it meet the oppoſite ſide, at *d*; then biſect *b d*, by a perpendicular *o a e*, at *a*; make *a o*, equal to *A O* on the elevation; then with a radius *o b*, deſcribe the arc *b e*; it will be the curve required.

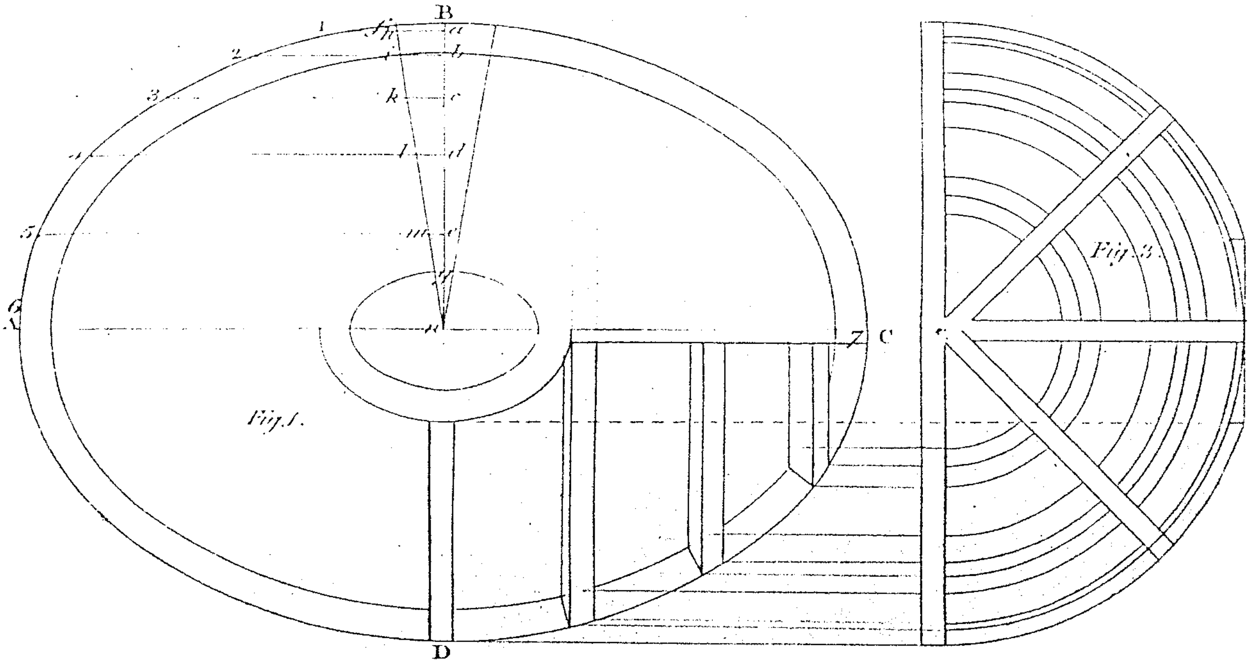
PLATE XIV.

ROOFS.

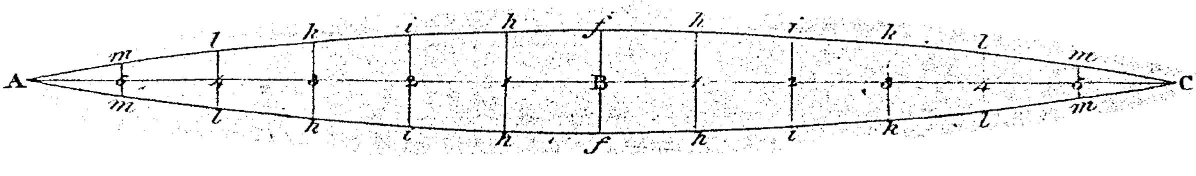
How to cover the whole of a ſpheroidical dome with one mould only, when the baſe or plan of this dome is a ſection, paſſing through the tranſverſe axis of the ſpheroid, or any other ſection parallel to it.

Let *A B C D* be a plan of the dome, which is a ſection; through the tranſverſe axis of a ſpheroid, let *B D* be the conjugate axis; divide one quarter of the plan *B A*, into any convenient number of equal parts, as ſix; from theſe points draw lines, 1 *h a*, 2 *i b*, 3 *k c*, 4 *l d*, &c.; parallel to the tranſverſe axis *A C*, cutting the conjugate *B D*, at the points *a*, *b*, *c*, *d*, and *e*; from *B* make *B* 8, equal to half of any of the equal diſtances, as between *B* and 1, or between 1 and 2, &c.; draw *f n* to the centre, cutting 1 *a*, 2 *b*, 3 *c*, &c. at the points *h*, *i*, *k*, *l*, *m*; from the point *B*, in the line *A C*, at No. 1, ſtretch out the arc *B A*, of the quadrant, at *fig.* 1, on the plan, as at 1, 2, 3, 4, &c. through theſe points, draw ordinates at right angles to *A C*; from the ſeveral points 1, 2, 3, 4, &c. in *A C*, No. 1, make the ſeveral diſtances 1 *h*, 2 *i*, 3 *k*, &c. equal to their correſponding diſtances, *B f*, *a h*, *b i*, *c k*, &c. on the plan, which will give points through which the curve may be completed. The manner of fixing the ribs of this dome is ſo ſimilar to plate 15, page 11, that no other deſcription is neceſſary; other differences are plain by inſpecting No. 3.





No 1



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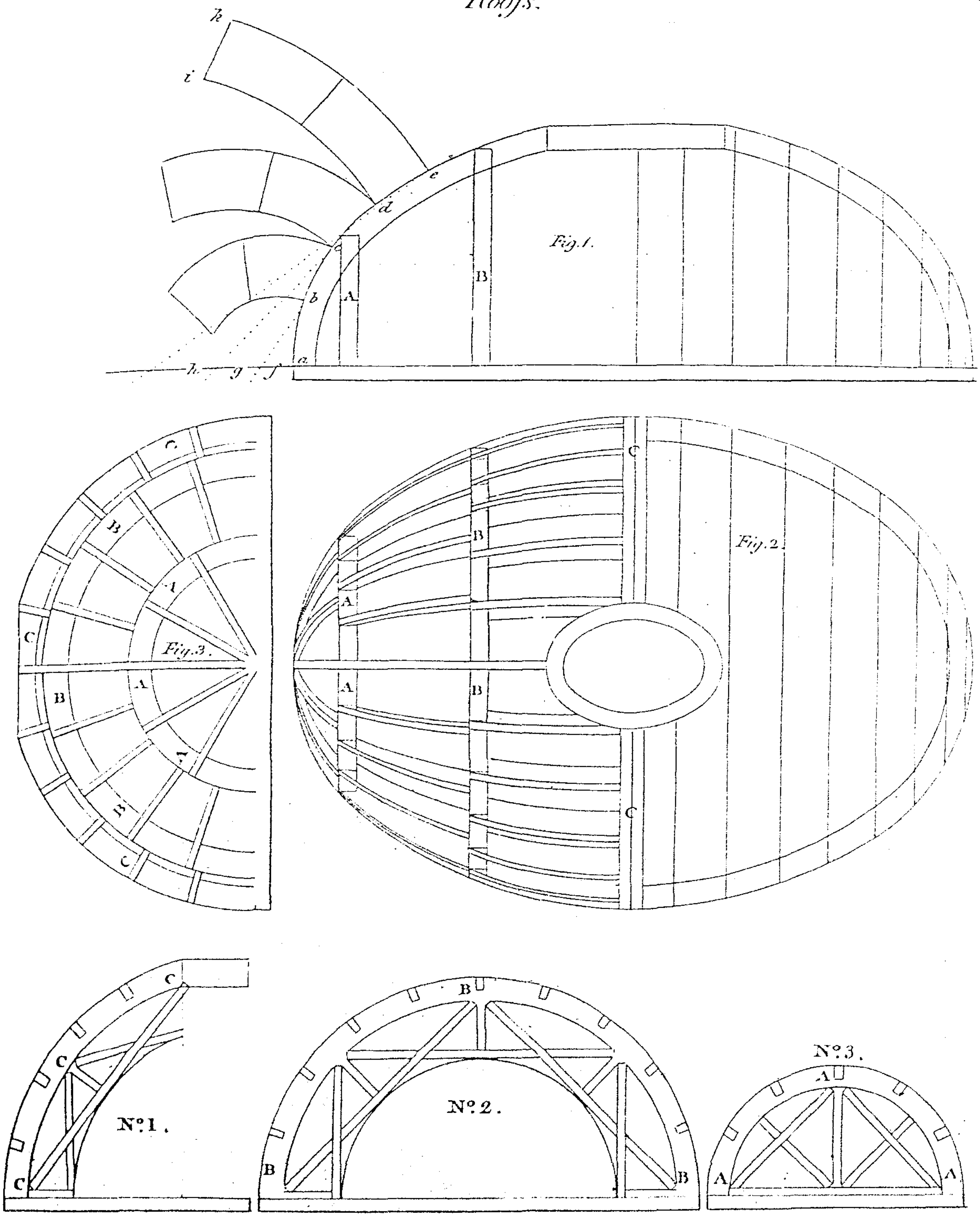

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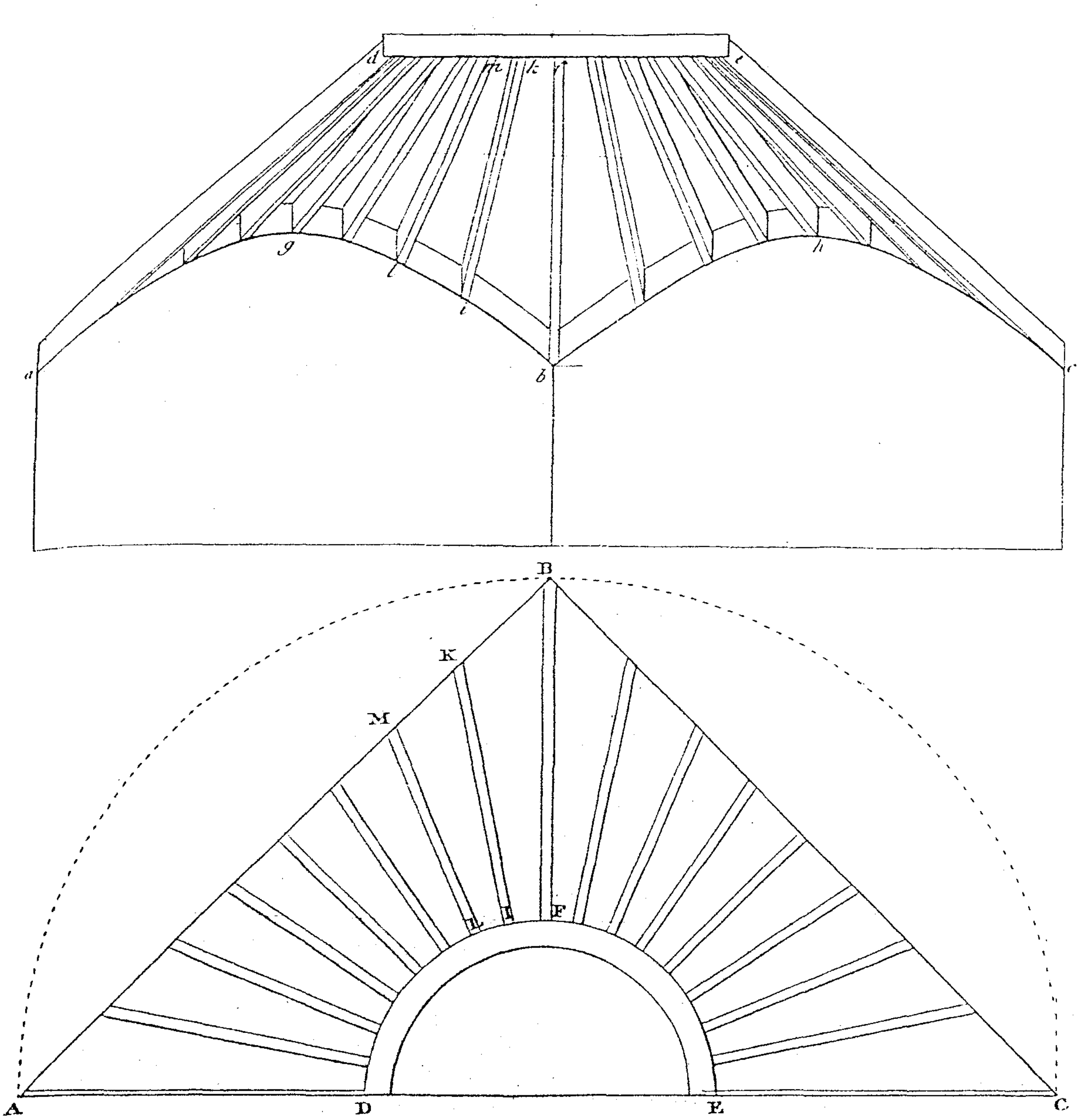

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PLATE XV.

ROOFS.

How to cover a ſpheroidical dome with boards, having all their joiſts in plains, perpendicular to the tranverſe axis of the dome.

FIG. 1, the ſide elevation, ſhowing the edges of the ribs at *A* and *B*, which are perpendicular to the plan, and parallel to each other.

FIG. 2, the plan, one half ſhowing the plan of the ribs as at *A A*, *B B*, and *C C*.

FIG. 3, the end elevation, which ſhows the ribs at *A A A*, *B B B*, *C C C*, which are all circular; acroſs theſe ribs are fixed ſmaller ribs, of the ſame curve as the plan, as is ſhown in the plan and end elevation. No. 1, ſhows the middle rib *C C*; on the plan *fig.* 2, No. 2, ſhows the rib *BB* on the plan, and No. 3, the rib *A A*, on the plan, or *A A A*, on the elevation; each of the principal ribs are notched on the upper edge, in order to receive the croſs ribs, as is ſhewn at No. 1, No. 2, and No. 3.

How to cover the dome.

On the elevation, *fig.* 1, take any equal parts as at *a*, *b*, *c*, *d*, and according as you think the width of a board will admit; now to find the curve of any board, ſuppoſe one to bend acroſs *d e*; through the points *e* and *d* draw the ſtraight line *e d h* meeting the axis at *h*; then on *h*, as a centre, with a radius *h d* deſcribe a circle, will be one edge of the board, and with a radius *h e*, deſcribe a circle, will give the other edge of a board for that place; in the ſame manner all the other boards will be found.

PLATE XVI.

ROOFS.

How to fix a conical top over a ſquare room.

Let *A B C* be half the plan of the room, and *D F E* be the half plan of a curb to which the ribs are all fixed at the top; the hyperbolical arches *a g b*, *b h c*, on each of the four ſides are all of the ſame height; in order to fix the ſtraight ribs *h f*, *i k*, *l m*, &c. which are alſo ſhown on the plan *F B*, *I K*, *L M*, &c. the manner of finding the hyperbolical curves, *a g b*, *b h c*, is ſhown in the next plate.

PLATE XVII.

ROOFS.

How to determine the interſections of a conical finiſh over any ſquare room, the diameter of the baſe of the cone being ſuppoſed equal to either of the diagonals of the ſquare, as K L *or* I M.

Biſect the diagonal *L K*, at the point *N*, by the perpendicular *N W*; make *N W* equal to the height of the cone; then draw the ſides *L W*, and *K W*; biſect the ſide *M K* of the ſquare at *a*; on the point *N*, with a radius *N a* deſcribe an arc *a A*, cutting the diagonal *L K*, at *A*; then take at pleaſure the points *B*, *C*, and *D*, between *A* and *K*, and with the ſeveral radii *N B*, *N C*, and *N D*, deſcribe arcs *B b*, *C c*, and *D d*, cutting *K M* at the points *d*, *c* and *b*; from the points *A*, *B*, *C*, and *D*, draw *A E*, *B F*, *C G*, and *D H* perpendicular to the diagonal *K L*, cutting the ſide *W K*, of the cone, at *E*, *F*, *G*, and *H*; at the points *a*, *b*, *c*, *d*, erect perpendiculars *a e*, *b f*, *c g*, and *d h*, to the ſide *M L*; make each of the diſtances *a e*, *b f*, *c g*, and *d h* equal to their correſponding diſtances, *A E*, *B F*, *C G*, and *D H* will give the edge of one half of the curve for that ſide, from which all the other may be traced; the ſhadowed parts on each of theſe curves ſhow the foot of the ribs ſo as to bring it to the curb at the top.

PLATE XVIII.

ROOFS.

How to fix the ribs of a ſpandrel dome ſtanding over a ſquare plan.

C D, *D E*, *fig.* 1. are two ſides of the plan; *A F B* is half the plan of the curb; *fig.* 2. is the elevation, in which is ſhewn the manner of fixing the ribs on two ſides of the plan; *a b* the elevation of the curb, correſponding to *A E B* on the plan; *c f d*, and *d g e*, are ribs placed on each ſide of the plan, which ſupport the vertical ribs which form the ſpherical ſurface; and theſe vertical ribs ſupport the curb *a f b*; on *a f b* is placed a ſky-light to admit of light to the ſtairs or room; this ſpandrel dome is to be finiſhed with plaiſter and conſequently the ribs muſt be at a near diſtance to each other at their wideſt places (about one foot or leſs from centre to centre).

PLATE

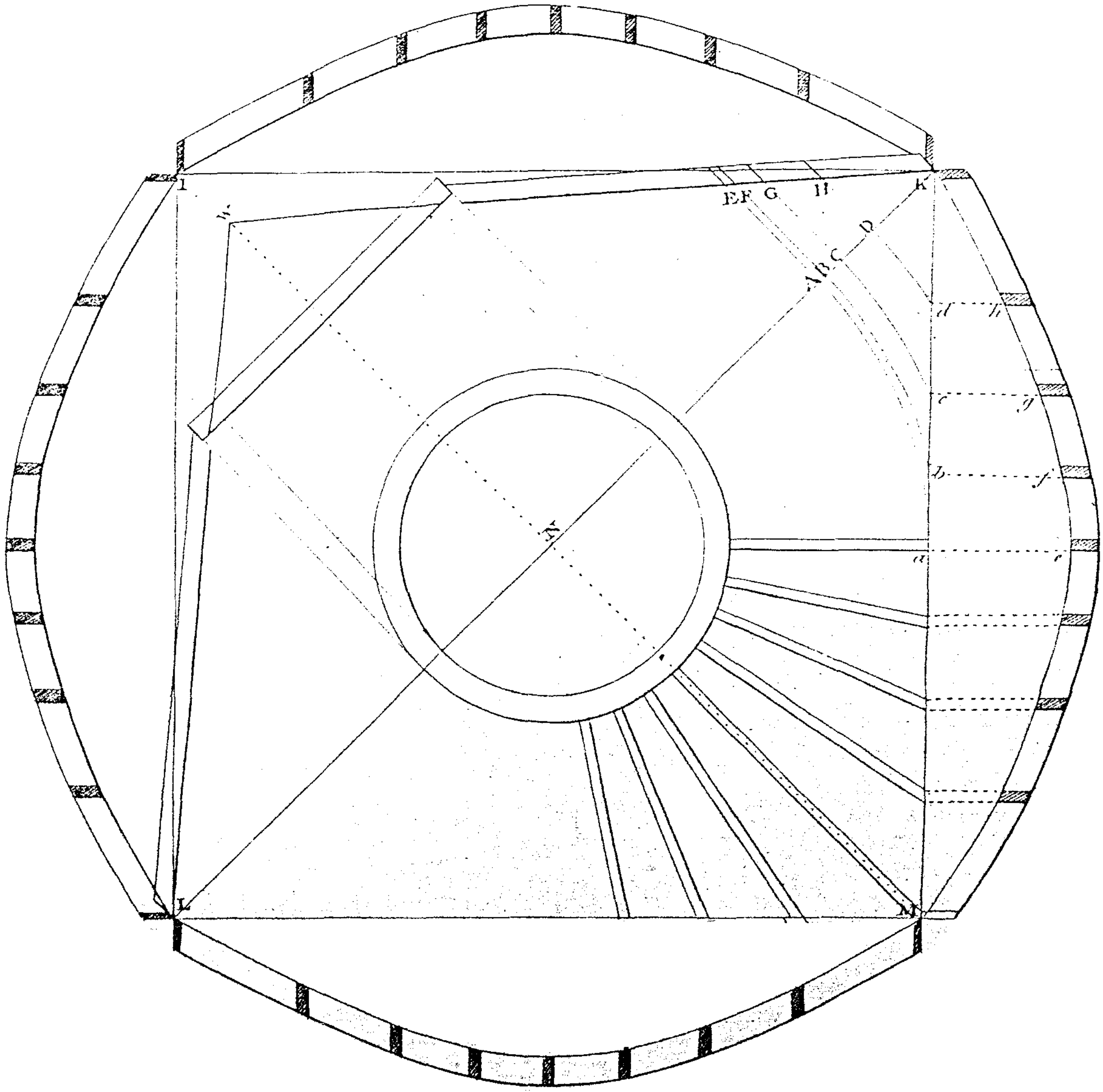

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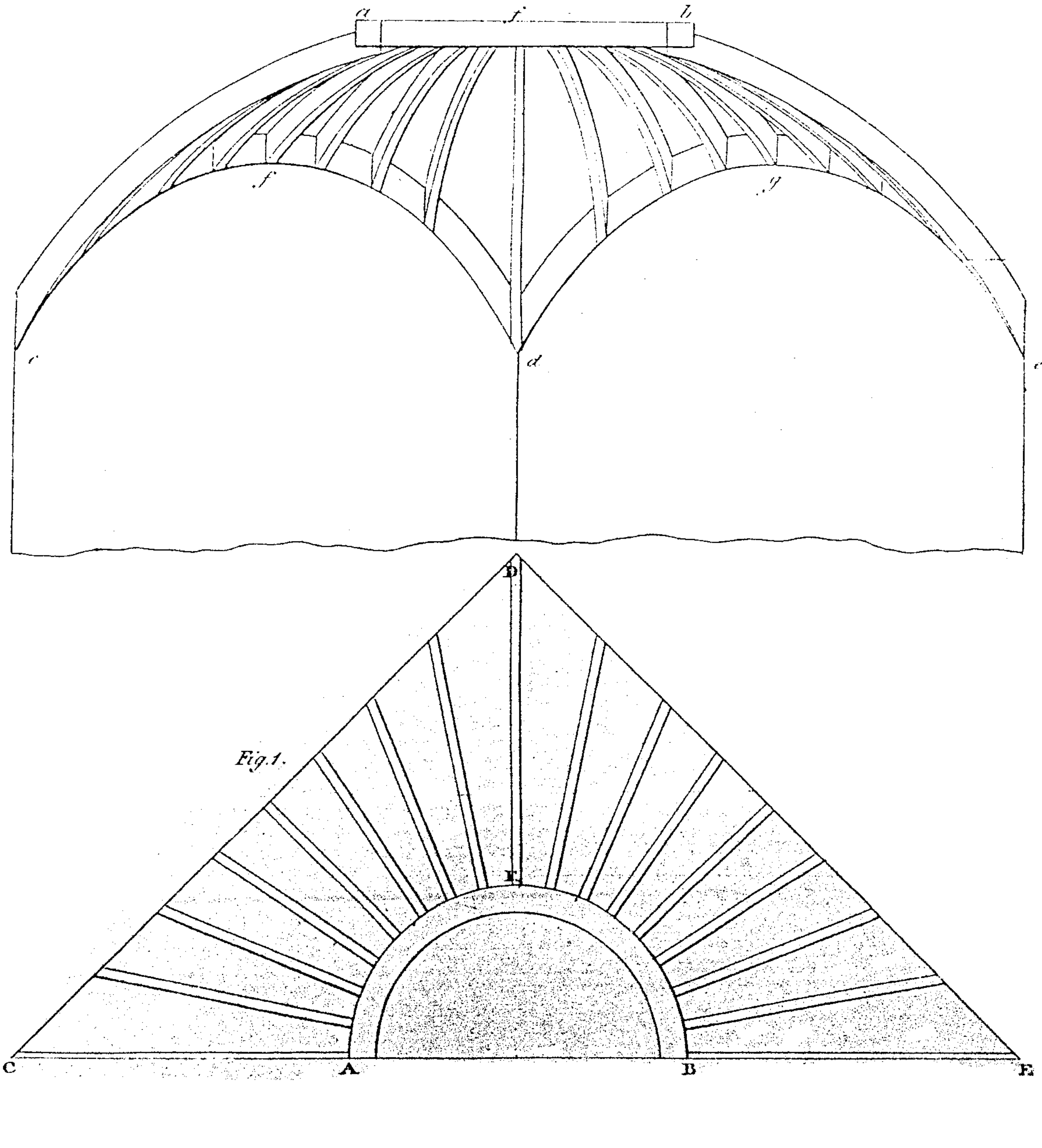
Fig. 2.



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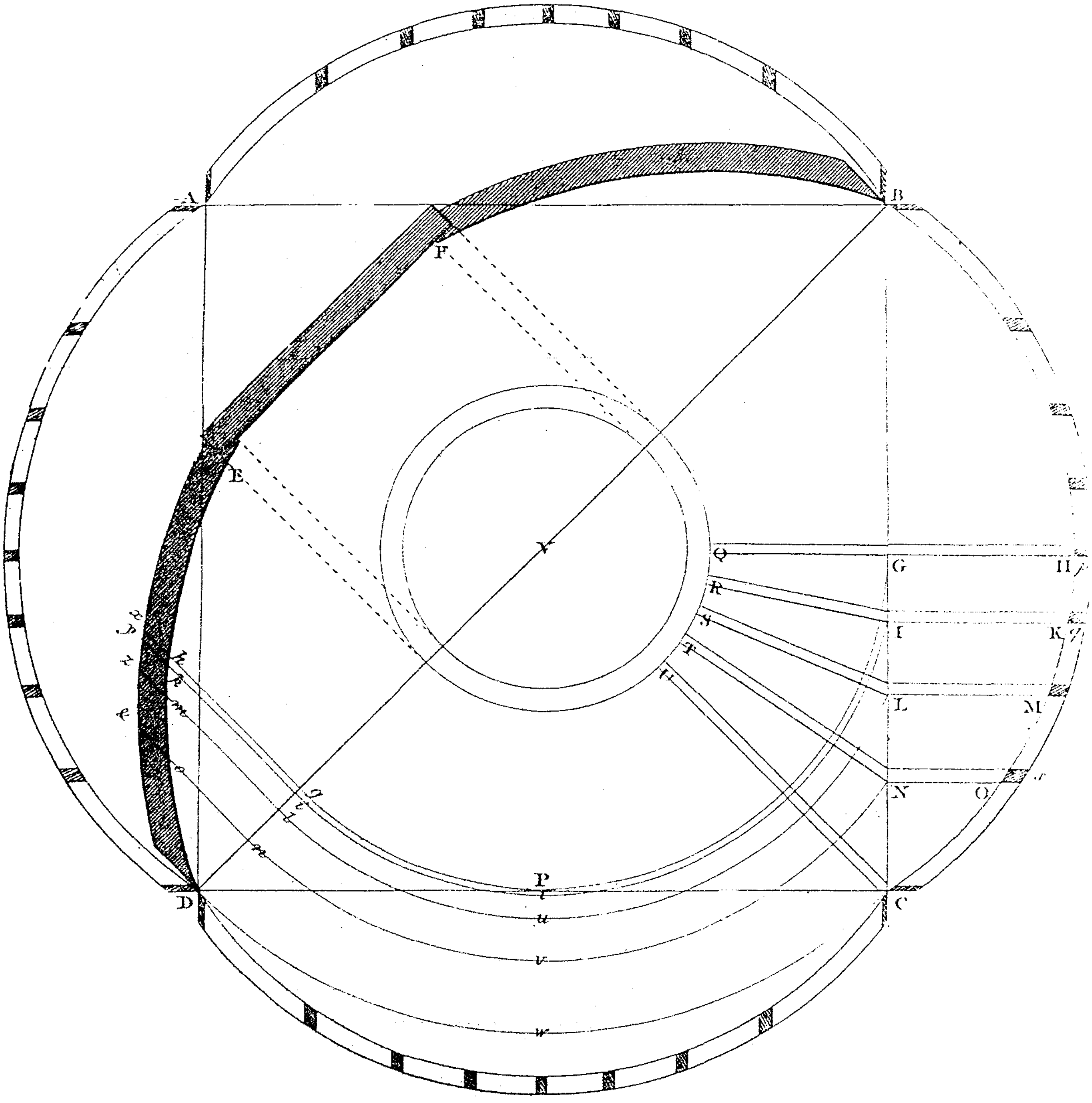

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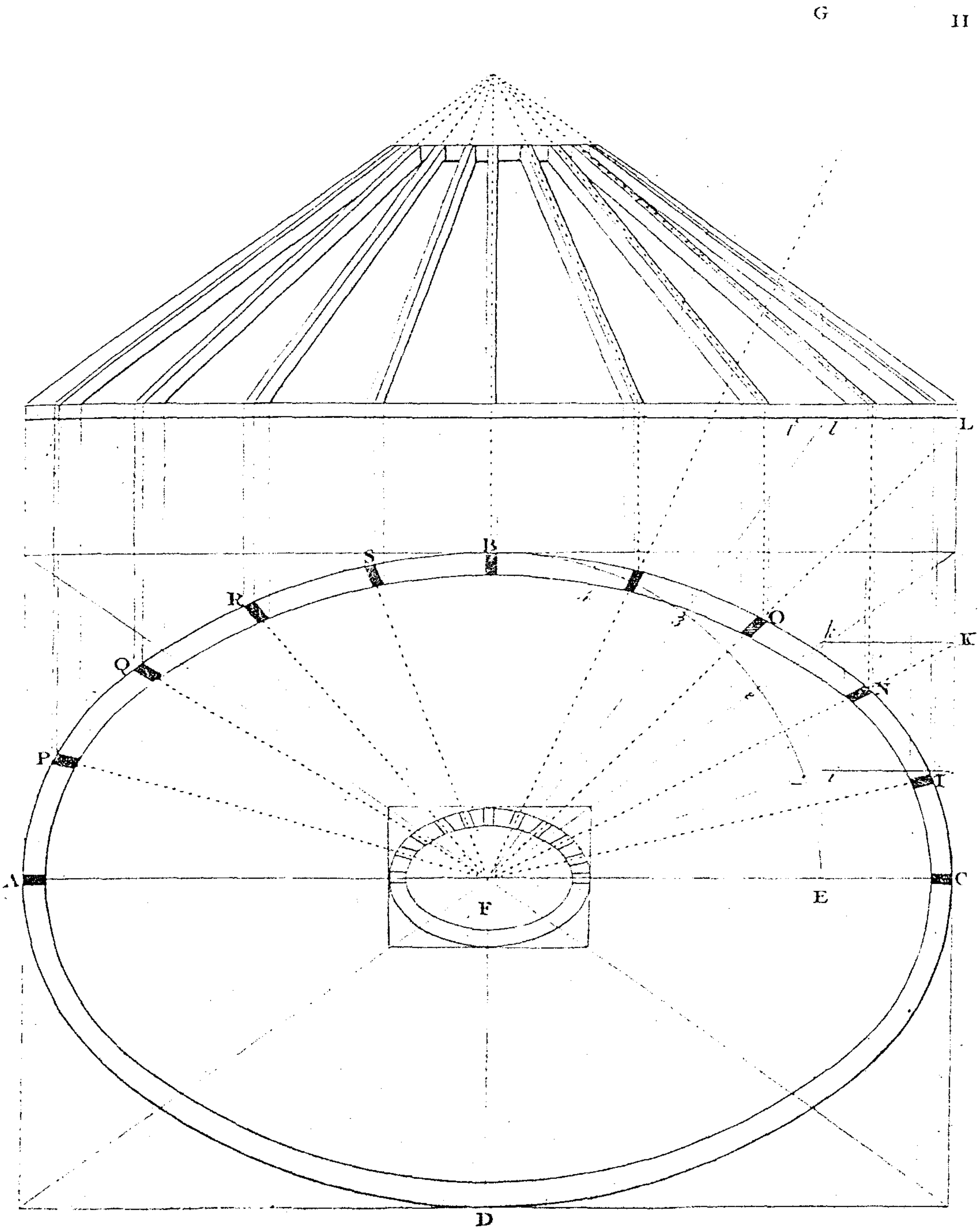

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PLATE XIX.

ROOFS.

To find the interfection of the ribs of a fpandrel dome, whofe fection is a given fegment of a circle, ftanding over a fquare plan, as in plate 17.

Let *A B C D* be the fquare plan, and let *D E F B* be a fection of the dome in the plane of the diagonal.

Firft lay down a plan of one quarter of the ribs, as are fhown at *U C*, *T N*, *S L*, *R I*, and *Q G*, fo that *Q G* is parallel to *D C* or *A B*, the fides of the fquare; on *V*, with the feveral radii *V G*, *V I*, *V L*, *V N*, and *V C*, defcribe arcs *G p g*, *I t i*, *L u l*, *N v n*, &c. cutting *D B* the bafe of the angular rib at *g*, *i*, *l*, and *n*; draw *g h*, *i k*, *l m*, and *n o*, each perpendicular to *D B*, cutting the diagonal rib at *h*, *k*, *m*, and *o*; then make all the diftances *G H*, *I K*, *L M*, and *N O*, equal to their correfponding diftances *g h*, *ik*, *l m*, and *n o*; and through the points *H*, *K*, *M*, *O*, draw a curve and it will give the under edge of the curve for the bottom of the ribs *Q G*, *R I*, *S L*, *T N*, and *U C*, which is alfo fhown complete on each fide of the fquare plan: now fuppofe each of the circular fegments as are fhown on each fide of the fquare plan to be turned up at right angles to the plan *A B C D*, the ribs will then ftand in their true pofition.

PLATE XX.

SKY-LIGHTS.

How to place the ribs of a conical fky-light, fo that their diftances fhall be proportional to the degree of curveture of the plan when it is elliptical.

Let *A B C D* be the plan, whofe centre is *F*; let *A C* be the tranfverfe axis and *B D* the conjugate; on *F*, with the femi-conjugate defcribe the quadrant *B E* cutting the conjugate at *B* and the tranfverfe in *E*; divide the quadrant *B E* into as many equal parts as you intend to have ribs in each quadrant: in this example it is in five at the points 1, 2, 3, 4; from the points *E* and *C*, draw the lines *E G* and *C H*, parallel to *B D* the conjugate axis; from the centre *F*, and through the points 1, 2, 3, 4, draw lines *F* 1 *i*, *F* 2 *k*, &c. cutting *E G* at *i*, *k*, *l*, &c.; through the points *i*, *k*, *l*, draw *i I*, *k K*, *l L*, &c. parallel to *A C*, the tranfverfe axis, cutting *C H* at *I*, *K*, *L*, &c.; from thefe points draw lines

lines to the centre at *F*, cutting the circumference of the plan at *I*, *N*, *O*, &c. for the place of the ribs.

On the other ſide of the plan the ribs are divided equally at *P*, *Q*, *R*, and *S*, where it will appear that the ſpaces towards the tranſverſe axis *A P*, *P Q*, appear too great for thoſe at the extremity of the conjugate, viz. *B S*, *S R*.

PLATE XXI.

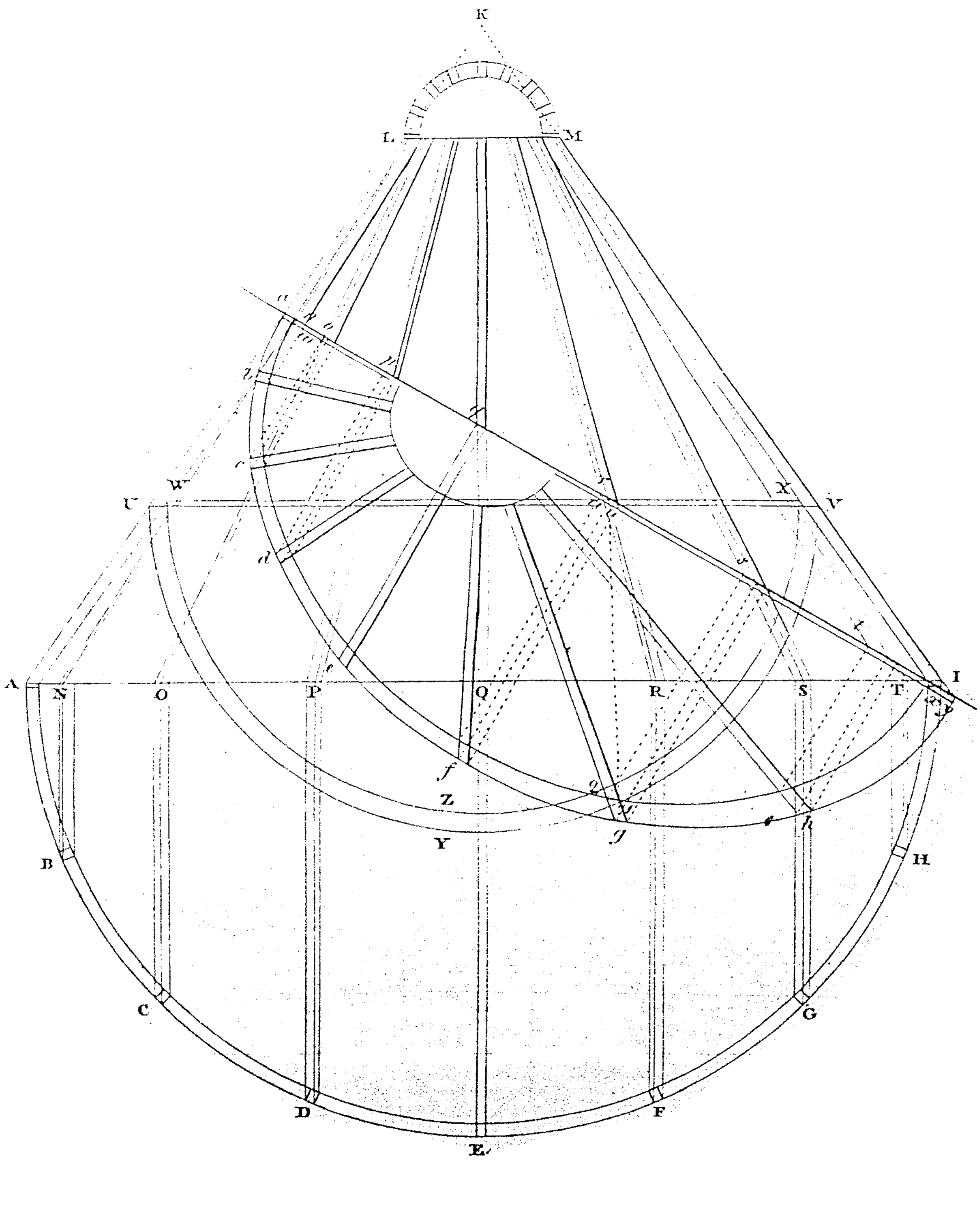
SKY-LIGHTS.

How to draw the curb of a conical ſky-light placed on the inclined ſide of a roof, the baſe of the cone being a circle, parallel to the horizon, and the axis of the cone perpendicular to its baſe.

Let *a y* be the inclined ſide of the roof, and let the vertex of the cone be at *K*, and let *K Q* be the axis of the cone; draw *K I* and *K A* making equal angles with *K Q*, cutting the inclined ſide of the roof at *a* and *y*; draw any line *A I* perpendicular to the axis *K Q* of the cone, cutting the ſides *K A* and *K I* of the cone at *A* and *I*, and the axis *K Q* at *Q*; then on *Q* with the radius *Q A* on *Q I*, deſcribe a ſemicircle *A B C D E F G H I*, on which place the plan of the ribs at *A B C D*, &c. from each plan at *B*, *C*, *D*, *E*, &c. draw lines from their angular points, each perpendicular to *A I*, cutting *A I* near *N*, *O*, *P*, *Q*, &c. from *N*, *O*, *P*, *Q*, &c. draw lines to the vertix at *K*, cutting *a y* at *n*, *o*, *p*, *q*, *r*, *s*, *t*; biſect *a y* at *V*, through *v* draw *U v V* parallel to *A I*, cutting the ſides of the cone at *U* and *V*; on *U V* deſcribe a ſemicircle *U Y V*; from *v* draw *v* 1, perpendicular to *U V*, cutting the ſemicircle at 1; make *v f* from *v* perpendicular to *a y* equal to *v* 1; then will *a y* be the tranſverſe axis of an ellipſis, and *v f* will be the conjugate, round which deſcribe the ſemi-ellipſis *a b c d e f g h y*, which will give one half of the curve for the curb; in the ſame manner you may proceed with the inſide of the curb, which has *w x* for the tranſverſe axis; then by drawing perpendiculars to *a y*, from *n*, *o*, *p*, *q*, *r*, &c. cutting the curb at *b c d e f g h*, will give the places of the ribs, and by drawing them to *q* will give their ſeveral directions.

PLATE

Sky Lights.



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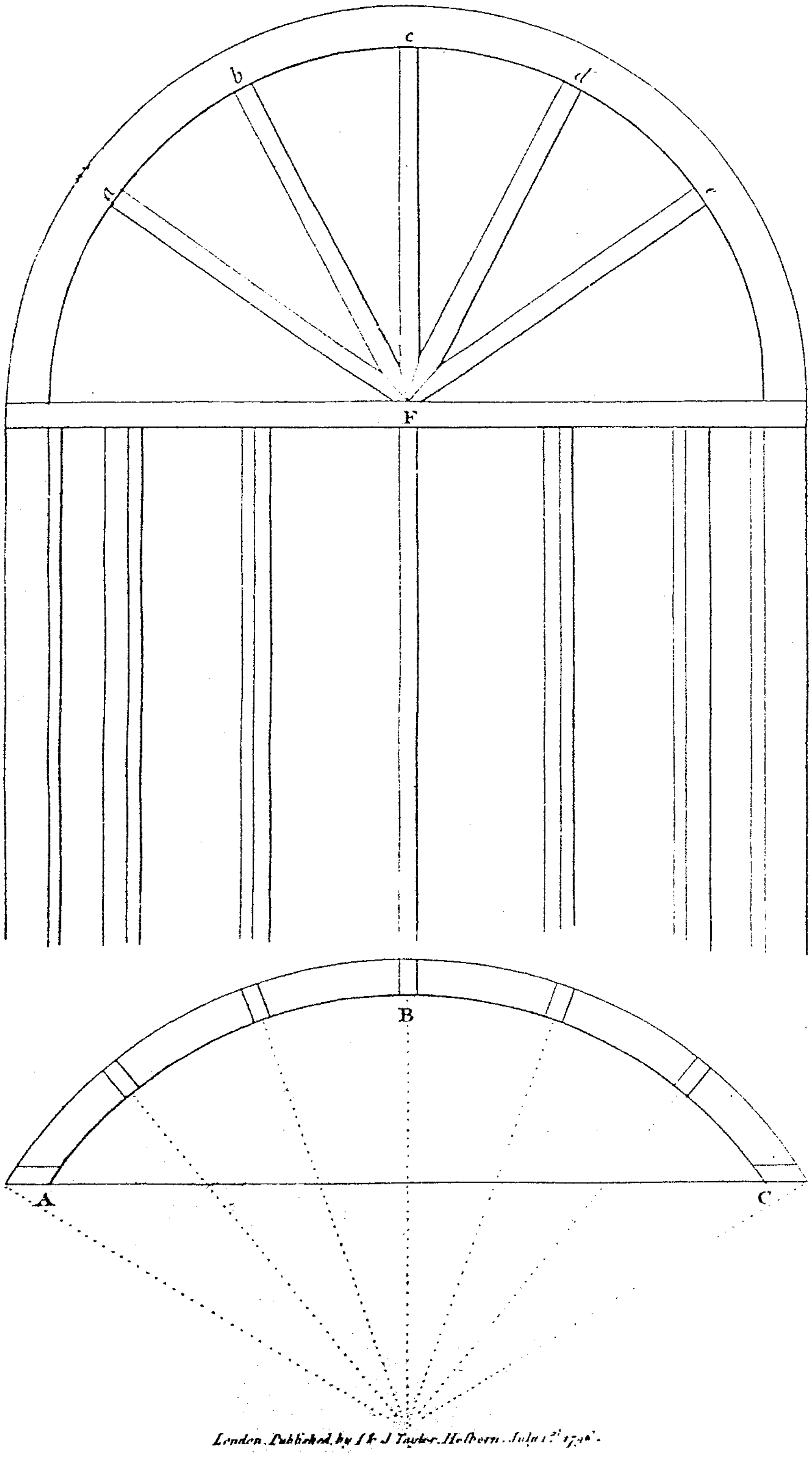

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Niches

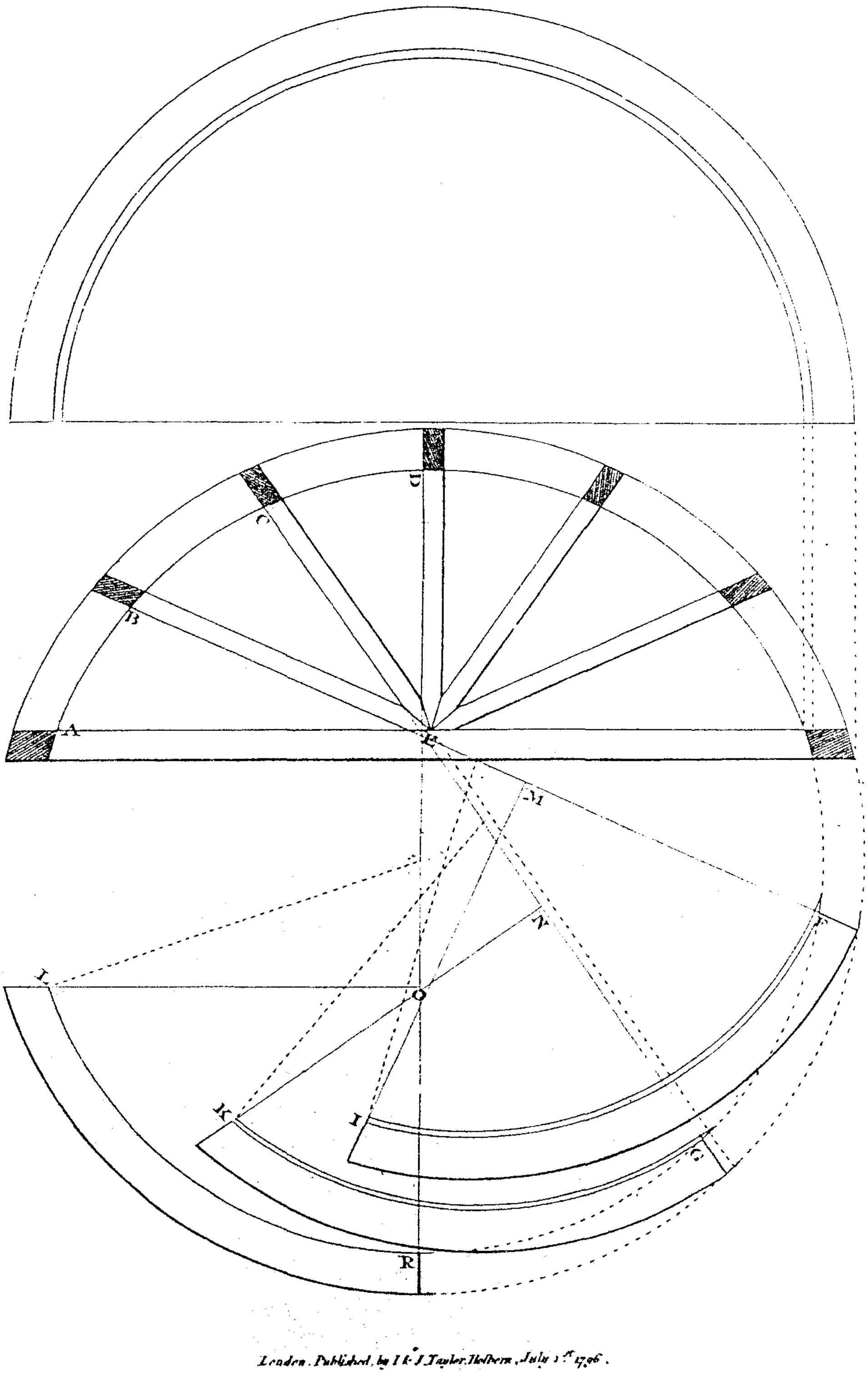

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PLATE XXII.

NICHES.

How to draw the ribs for the top of a niche, the head being a ſemicircle and the plan a ſegment.

Let *A B C* be the plan of the niche, then one half, as *A B* or *B C*, will give any one of the ribs which are to be fixed upon the front rib at *a*, *b*, *c*, *d*, *e*, equally ſpaced, and to mitre together upon the back at *F*.

PLATE XXIII.

NICHES.

To find the ribs of a ſpherical niche which is the ſegment of a circle on the plan, and a ſemicircle on the elevation, the ribs not to tend to the centre of the ſphere, but to a point in the back of the front rib of the niche.

Let *A E*, *B E*, *C E*, and *D E* be the plan of half of the ribs; now, in order to find a rib ſtanding over any of theſe plans, ſuppoſe over *B E*, produce it out to *F*, cutting the circumference of the plan at *F* make *F M* equal to *B E* on *B F*, as a diameter; deſcribe a part of a circle *F I* from *M*; draw *M I* perpendicular to *M F*, cutting the arc at *I*, then will the arc *F I* be the under edge of the rib, ſtanding over *E B*; the breadth of the ribs may be what is thought proper: all the other ribs are deſcribed in the ſame way by producing their plan to the oppoſite ſide of the circumference.

Note. Be careful that each rib be backed to the plan, as is ſhewn in the ribs *F I*, *G K*, and *R I*.

PLATE

PLATE XXIV.

NICHES.

How to describe the ribs of a niche when parallel to each other, whose top is part of a globe, the plan being the segment of a circle and the elevation a semicircle.

Draw the plan and elevation of the ribs; from the centre *C* of the plan, and with the radius *C L* draw the inside circle of the plan all round, produce the ribs till they meet the opposite side of the plan at *I*, *F G*, *C D*; through *C* the centre of the plan draw *M C N*, parallel to *K R L*, the face of the niche, which will cut the plan of the ribs produced at *A* and *B*, on the points *C A* and *B*, as centres; with the radii *C I*, *A F*, and *B C*, respectively describe arcs *I W*, *F V*, and *C T*; and from the points *G* and *D* draw the lines *G H* and *D E*, perpendicular to the plan of the ribs, cutting the base of them at *H* and *E*; then again, on the centres *A* and *B*, with the radii *A H* and *B E* respectively, describe arcs *H U* and *E S*; then will *I W* be the inside of the rib at No. 1. and *F V*, and *H U*, the inside and backing of the arch No. 2; likewise *C T* and *E S*, the inside and backing of No. 3; the outside lines, representing the width of these arches, must be taken according to the discretion of the workman.

Note.—The ribs No. 1, 2, and 3, correspond to the plans marked 1, 2, and 3.

PLATE XXV.

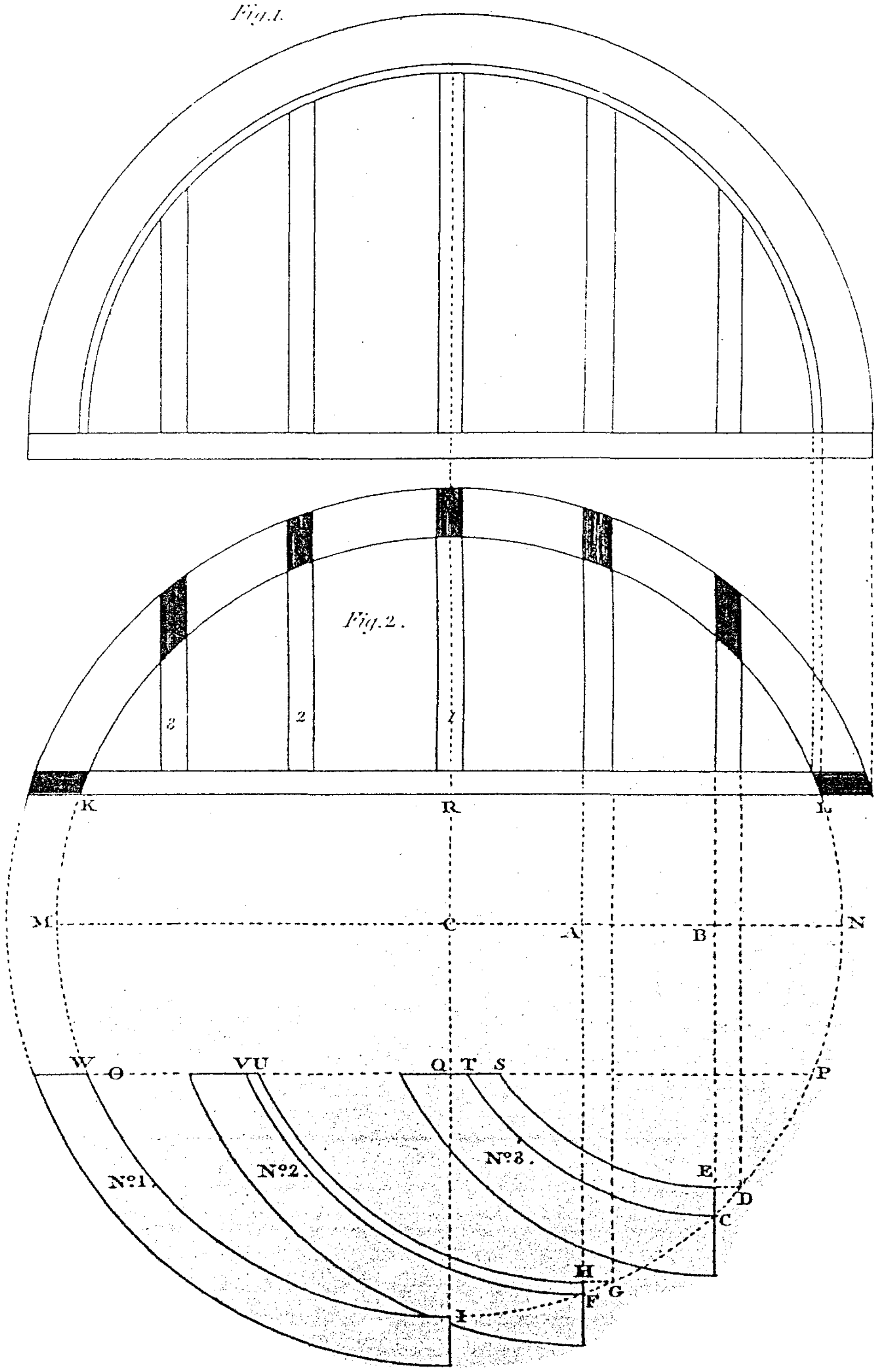
NICHES.

How to draw and fix the ribs of a circular niche in a circular wall, by an easy practicable method.

Let *A b c d* be a plan of the inside of the wall *A B C D*, the inside of the ribs of the niche which are all drawn towards the centre at *E*, that is the middle of the plan of each rib, will pass through *E* the centre of the niche; take either of the distances *E A*, *E B*, *E C*, &c. and with that distance take any points *H*, *G*, and *F*, at No. 1, No. 2, No. 3, as centres, and describe arcs *B I K*, *C L M*, and *D N*, which will be the inside of each rib; draw the radius of each, that is *B H*, *C G*, and *D F*.

How

Fig. 1.



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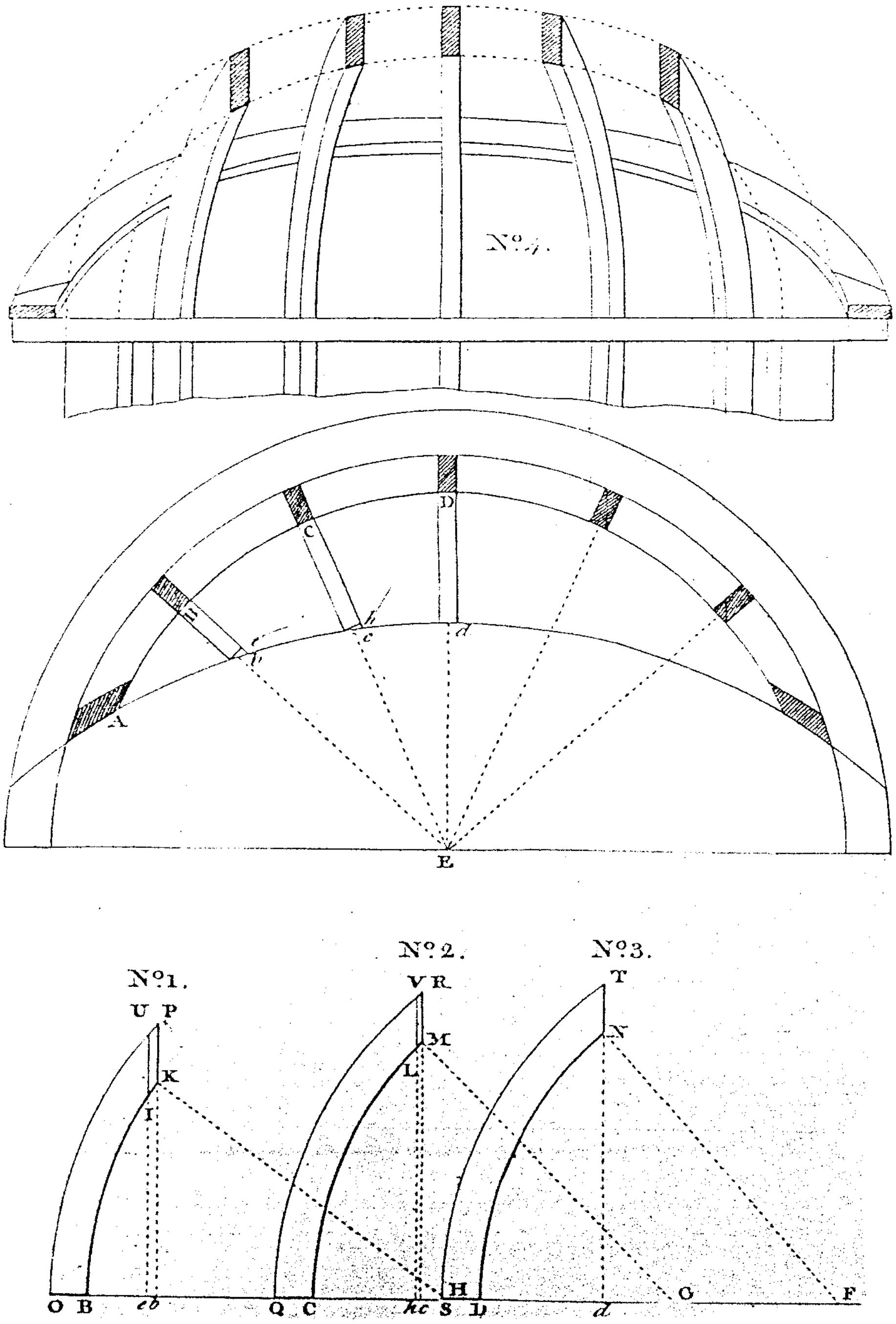

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How to cut the ribs to the face of the circular wall.

From *B*, *C*, and *D*, at No. 1, No. 2, No. 3, make the diſtances *B b*, *C c*, and *D d*, reſpectively equal to *B b*, *C c*, and *D d*, on the plan; from the points *b*, *c*, and *d*, at No. 1, No. 2, No. 3, draw *b K P*, *c M R*, and *d N T*, reſpectively perpendicular to *B H*, *C G*, and *D F*, cutting their circle in *K*, *M*, and *N*; then will *B K*, *C M*, and *D N*, be the length; on the inſide of each rib take the little diſtance *b e*, *c h*, from the plan, and at No. 1, No. 2, No. 3, make *b c*, *d h*, equal to them; draw *e I U*, *h L V*, reſpectively parallel to *b K P* and *c M R*, and the diſtance of the parallel lines *I U*, *K P*, and *M R*, *L V*, will ſhow the bevel of each rib ſo as to anſwer the face of the wall; No. 4, ſhows the manner of fixing the ribs, which muſt be perpendicular to the plan, and, to keep the ribs ſteady, a circular rib may be fixed acroſs the backs, whoſe inſide will be a part of the ſame circle as the back of the ribs.

OF FIXING GROUNDS.

Grounds are framed pieces of timber attached to the wall, going round windows, doors, or any other opening in buildings, in order to fix an architrave or any other kind of moulding upon them; in theſe caſes all grounds ought to ſtand perpendicular to the horizon, that is, in workmen's terms, to be plumb face and edge, and great care ought to be taken in fixing them perfectly firm and ſolid in every part, for on their accuracy depends the well finiſhing of all the inſide work; and if in plaiſter, it ought to be floated to them, and the firmly fixing of the architrave will depend much on their ſolidity.

In fixing grounds for windows, the ſaſh frame ought to be carefully fixed firſt, and to ſtand quite perpendicular, or plumb; be careful that the face of the ground ſtand quite parallel to the face of the ſaſh frame, and to project about three-fourths of an inch from the face of the naked brick-work, ſo as to leave a ſufficient ſpace for the thickneſs of the plaiſter. The edge of the ground ought to be in the ſame plane with the edge of the ſaſh frame (that is, in workmen's terms, out of winding). The edge of the architrave, when finiſhed, is to ſtand about three-eights of an inch within the inner edge of the ſaſh frame, ſo that a perpendicular line down the middle of the grounds, ought to ſtand exactly oppoſite to a perpendicular line down the middle of the ſaſh frame.

LAYING OF FLOORS.

The true excellence of a floor is, that it be perfectly level; but experience teaches us that the nature of wood will not admit of its being made perfectly level, for as every floor has always a certain degree of weight in itſelf, ſo it will have a certain degree of ſinking from the laws of gravation, in thoſe places where it is not ſupported, until the moiſture is quite dried out of the wood, and conſequently there ſhould be a certain degree of riſing or cambering in the floor (about one inch in 20 feet), ſo that it ſhould be as near to a plane

as poſſible when it is ſettled, or the moiſture is dried out. But notwithſtanding grounds ſhould be perpendicular, and floors horizontal, yet we are often obliged to ſacrifice theſe perfections, to ſuit other conveniences, as will be ſhewn in the inſtructions for hanging doors.

PLATE XXVI.

MITERING.

FIG. 1, the method of mitering dodo together at any exterior angle of a room.

Note.—In fixing this together, you may drive in brads from each ſide.

FIG. 2, the method of fixing troughs together or any rectangular wooden veſſel.

FIG. 3, the method of putting dodo or ſkirting together at any interior angle of a room; this is alſo uſed for water trunks.

FIG. 4, the manner of fixing and finiſhing two pieces of framing together at the angle of their meeting with a returned bead, in order that the joint ſhould not be ſhewn: this is only uſed in common finiſhings; in good finiſhings, a ſmall three-eight bead is only uſed at the joint, keeping the angle entire. This is the beauty of joiner's work, to ſhow all angles as ſharp as poſſible: ſome finiſh without any bead at the joint, as in *fig.* 6, where the joint is made as cloſe as poſſible and well glued together; and if it ſhould be required to be ſtronger, you may glue blockings in the angle, which will keep it firm.

FIG. 5, is another method of mitering; this is not ſo ſtrong as *fig.* 1, as it has no butment.

In glueing up large work, all the edges that are to be glued, ought to be put before a fire ſo as to be well warmed, and then to be immediately glued, taking care at the ſame time that the glue is as hot as poſſible, for glue never holds well when it is chilled or cold.

PLATE

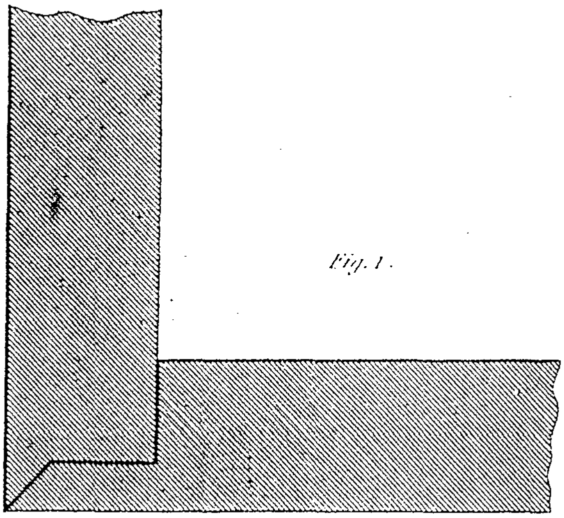


Fig. 1.

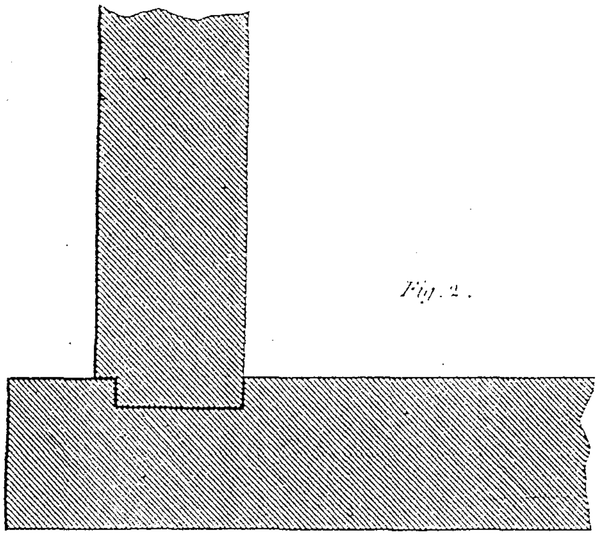


Fig. 2.

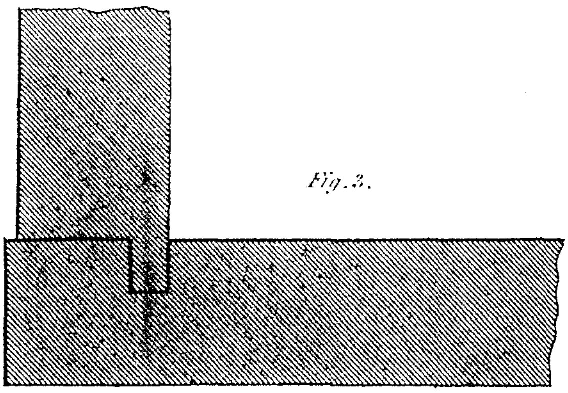
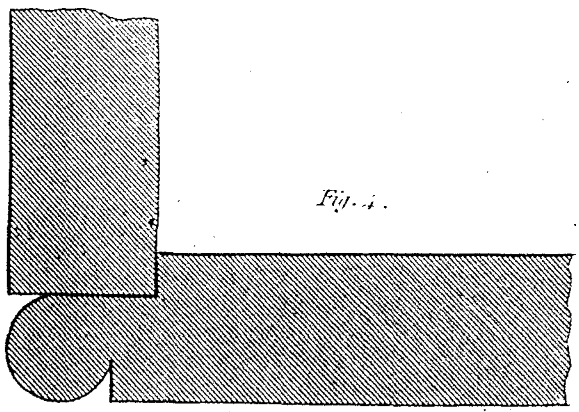


Fig. 3.



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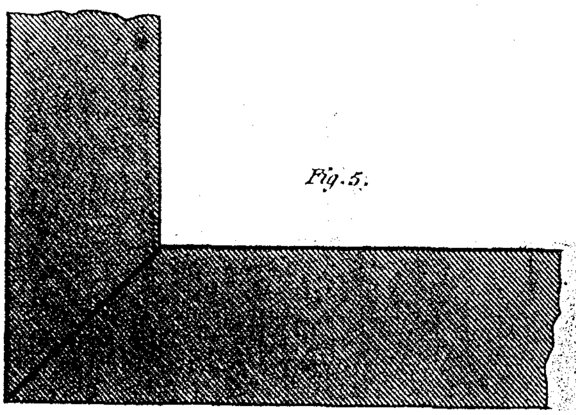

Fig. 5.

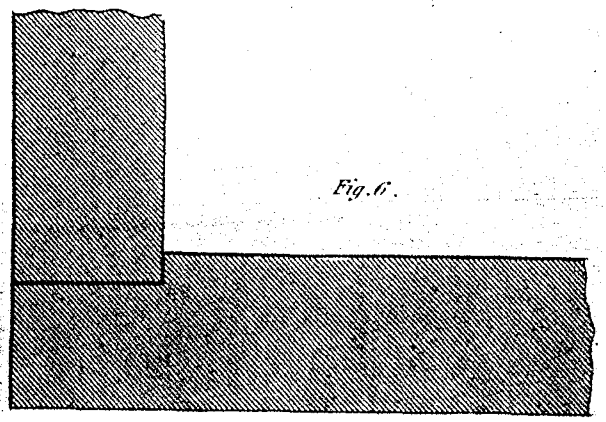

Fig. 6.

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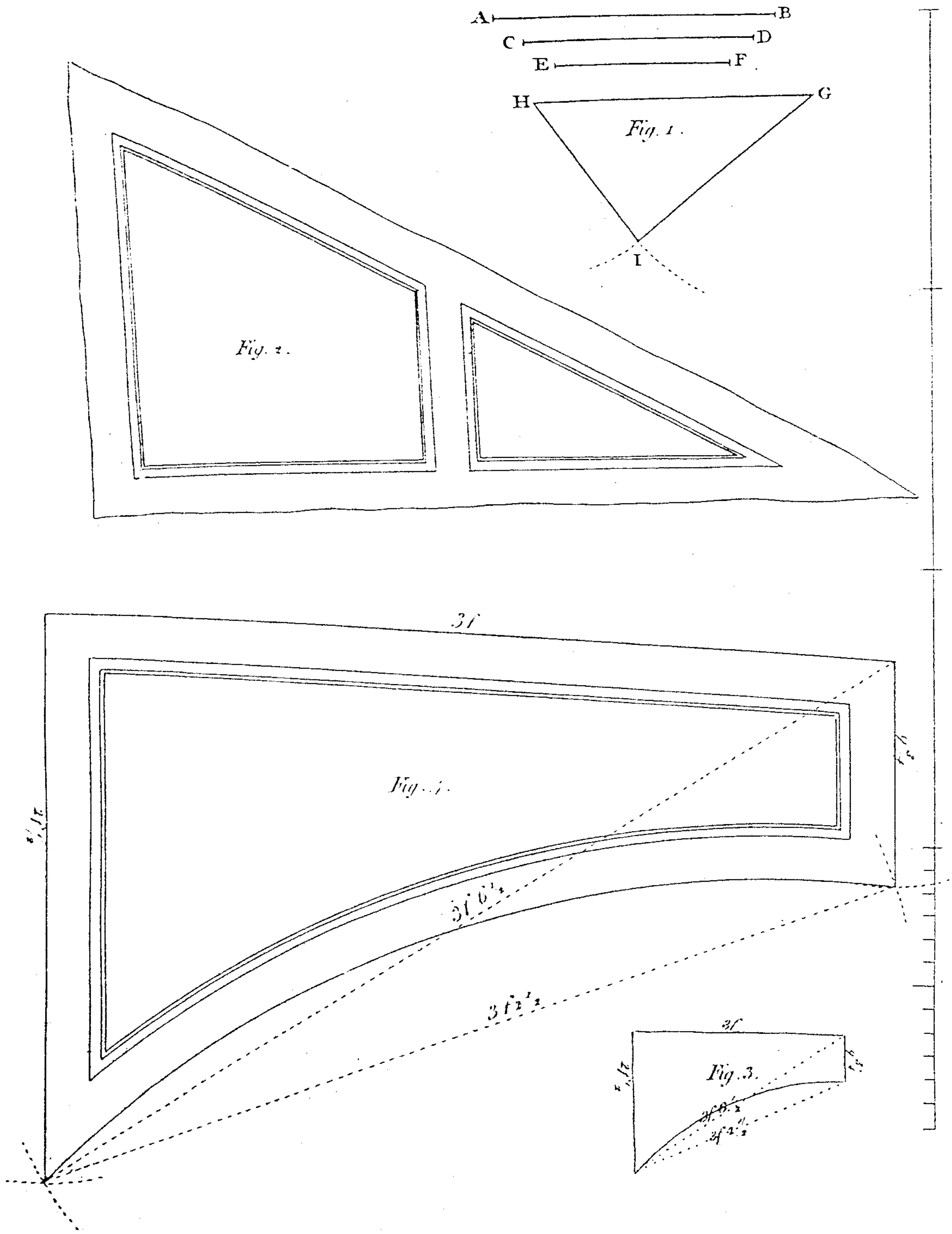

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Hingeing.

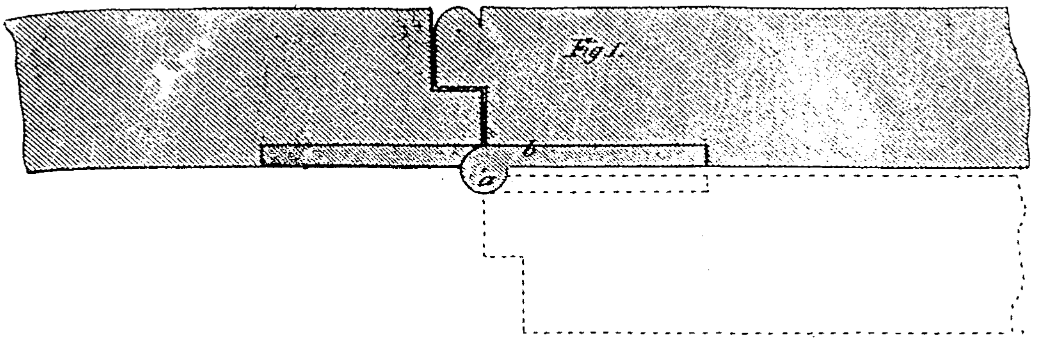

Fig. 1.

Fig. 2.

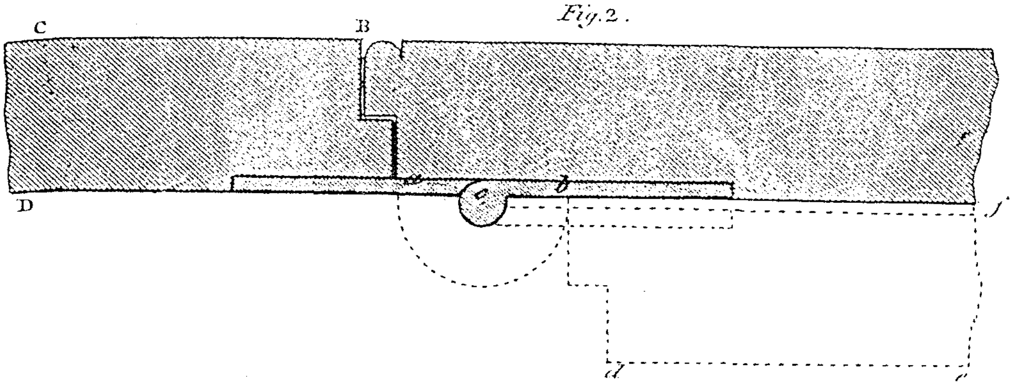

Fig. 3.

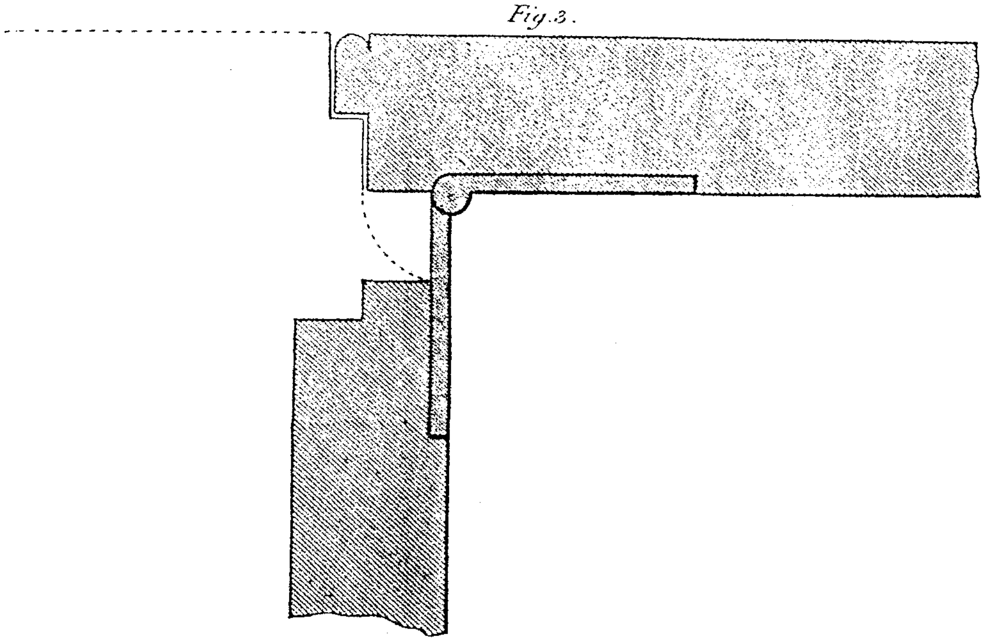

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PLATE XXVII.

OF TAKING DIMENSIONS.

Three ſtraight lines, AB, CD, and EF, being given to make a triangle, if any two are greater than the third,

FIG. 1, make HG equal to AB on H, as a centre; with a radius, EF, deſcribe an arc at I on G, as a centre; with the radius CD deſcribe an arc, cutting the former at I; join HI and GI; then will HGI be the triangle required.

By this rule (as *fig.* 2) may a piece of boarding or wainſcotting be fitted into any triangular ſpace; if the ſides of the ſpace are irregular, it will be beſt to fit pieces into each ſeparately; then lay the angular points together according to their places, and you may proceed as in deſcribing a triangle.

FIG. 3. Suppoſe it were required to take the meaſures of a ſoffit, without uſing any bevel, firſt make an eye drawing of it, as is ſhown at *fig.* 3; then meaſure the length of each ſide, and one of the diagonals; and if one of the ſides is curved, you muſt meaſure the riſe of that curve and mark on the ſketch; then you may deſcribe it as is ſhown in *fig* 4.

PLATE XXVIII.

HINGEING.

The principles of hanging doors, ſhutters, or flaps, with hinges.

The centre of the hinge is generally put in the middle of the joint at a, *fig.* 1; but in many caſes there is a neceſſity for throwing back the flap to a certain diſtance from the joint: in order to effect this, ſuppoſe you wanted the flap, when folded back, to be at a certain diſtance, as $a\ b$ in *fig.* 2, from the joint; divide $a\ b$ in two equal parts at the point c, which will give the centre of the hinge; the dotted lines $b\ d\ e\ f$, ſhows the poſition when folded back.

Note.—The centre of the hinge muſt be placed a ſmall matter beyond the ſurface of the door or ſhutter, otherwiſe the one will not fold freely back on the other.

It muſt alſo be obſerved, that the centre of the hinge muſt be on that ſide that the rabbet is on, otherwiſe it will not open without the joint being conſtructed in a particular form which will be afterwards ſhown.

FIG. 3, ſhows the ſame thing opened to a right angle.

PLATE XXIX.

OF PLACING HINGES, &c.

How to hang two flaps, or doors, so that when they are folded back, they shall be at a certain distance from each other.

This is easily accomplished by means of hinges having knees projecting to half that distance, as is plainly shown by *fig.* 1; this sort of hinges are used in hanging the doors of pews, in order to clear the moulding of the caping.

To make a rule joint for a window shutter, or for any folding flaps whatever.

Let *a*, *fig.* 2, be the place of the joint; draw *a c*, at right angles, to the flap shutter or door; take *c*, in the line *a c*, for the centre of the hinge; take the plain part *a b*, according as the workman shall think proper, on *c*; with a radius *c b*, describe the arc *b d*, then will *a b d* be the true joint.

Note. The knuckle of the hinge is always placed in the wood, because the farther it is in the wood the more of the joint will be covered, when it is opened out to a right angle, as in *fig.* 3; but if the centre of the hinge was placed the least without the thickness of the wood, it would show an open space, which would be a defect in workmanship.

PLATE XXX.

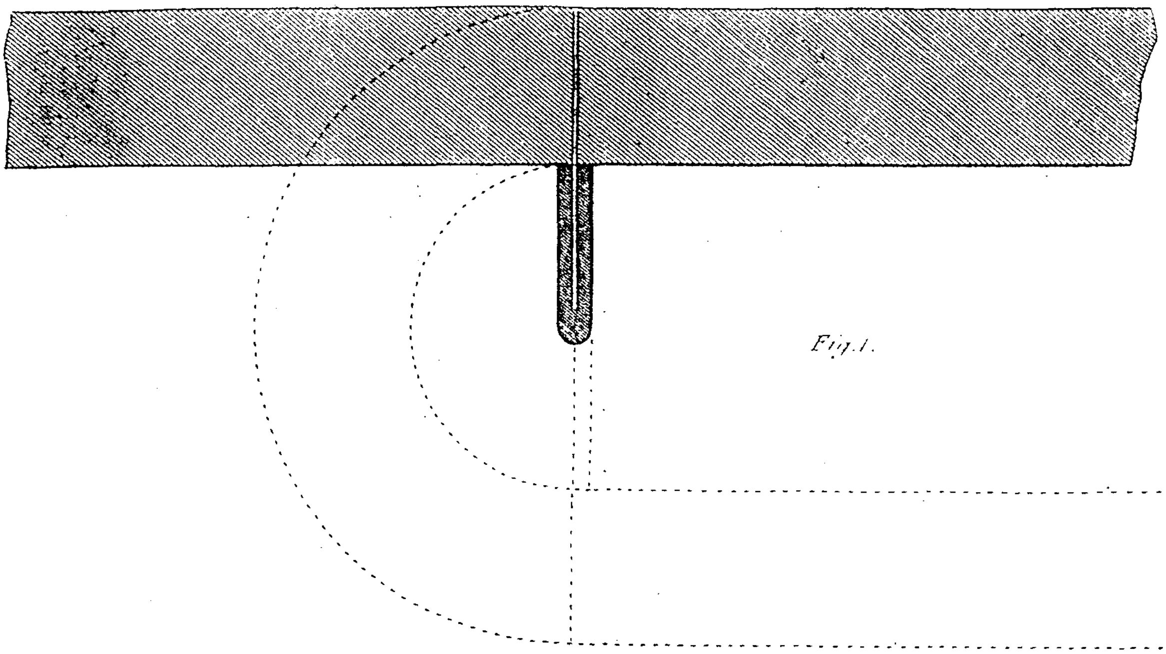
OF PLACING HINGES, &c.

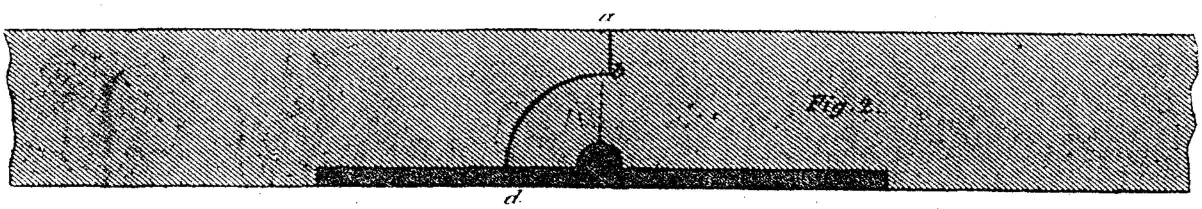
How to make the joints of styles, which are to be hung together when the knuckle of the hinge is placed on that side that the rabbet is on.

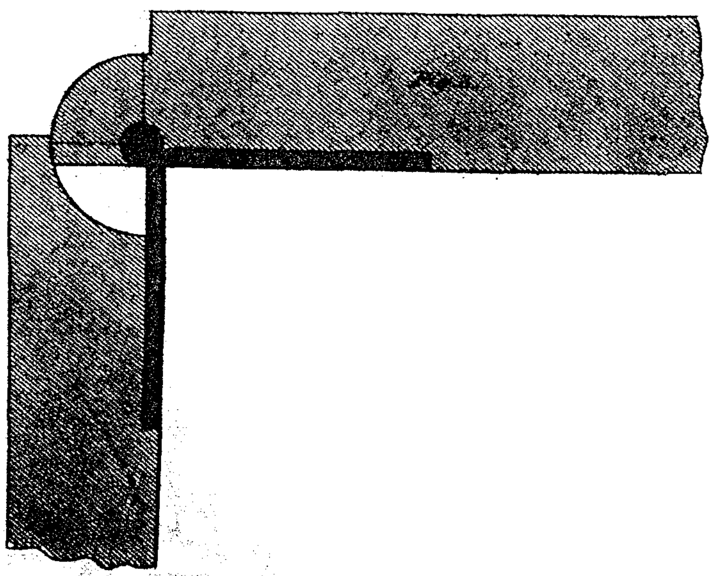
Let *C* be the centre of the hinge, *M I* the joint on the same side of the hinge; *K L* the depth of the rabbet in the middle, of the thickness of the styles, perpendicular to *K M* and *L F*, the joint on the other side, parallel to *K M*; bisect *K L* at *H*, join *H C* on *H C*, describe a semicircle *C I H*, cutting *K M* at *I*, through the points *I* and *H*; draw *I H G* cutting *F L* at *G*, then will *F G I M* be the true joint; but if the rabbet were made in the form *M K L F*, neither of the styles could move round the joint or hinge; *C*, *fig.* 2, shows the styles to one third part of the size of *fig.* 1. folded back; *fig.* 3. shows how to perform the same, by means of a circular joint, whose centre is the centre of the hinge.

PLATE

Hingeing.







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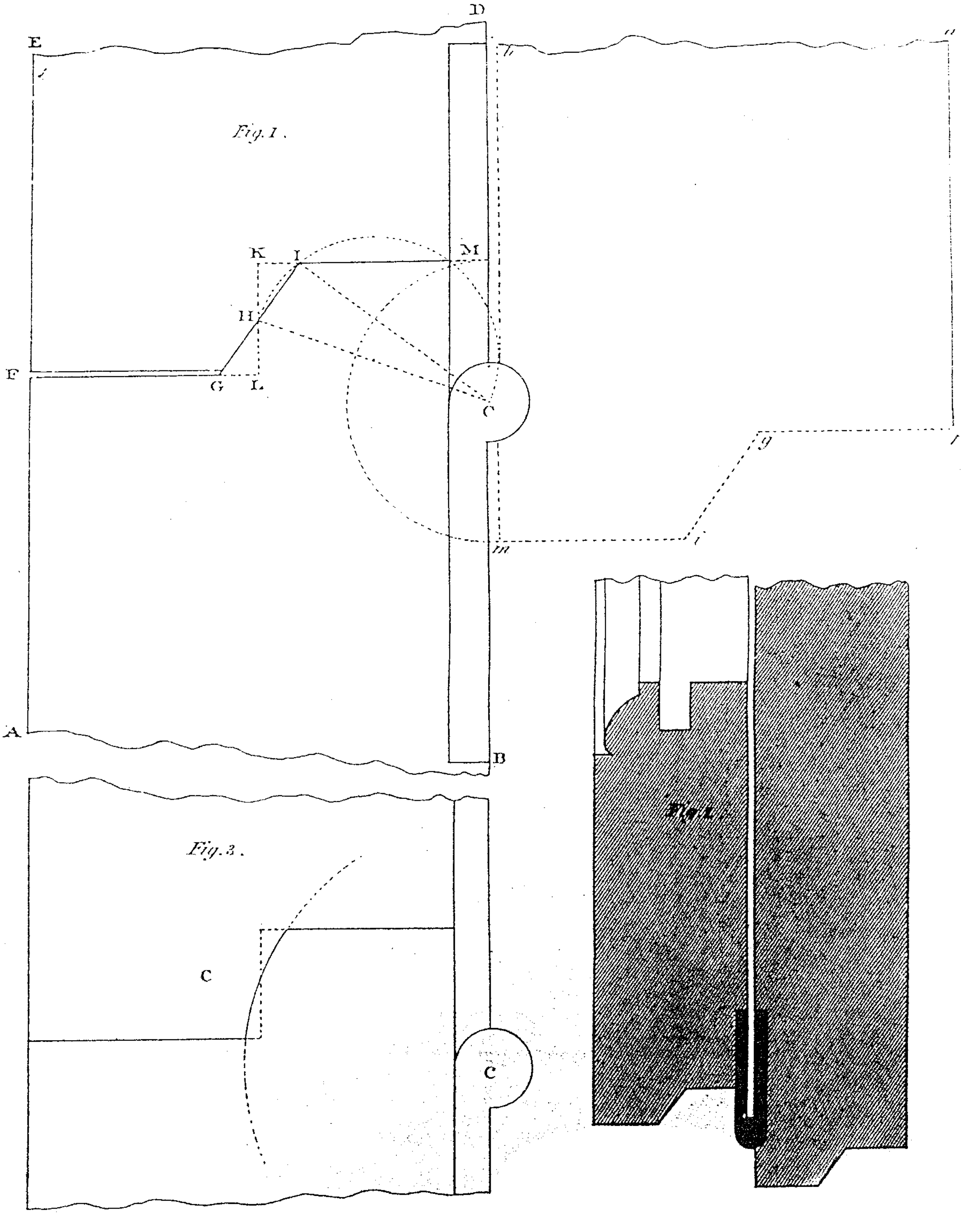
Hingeing.



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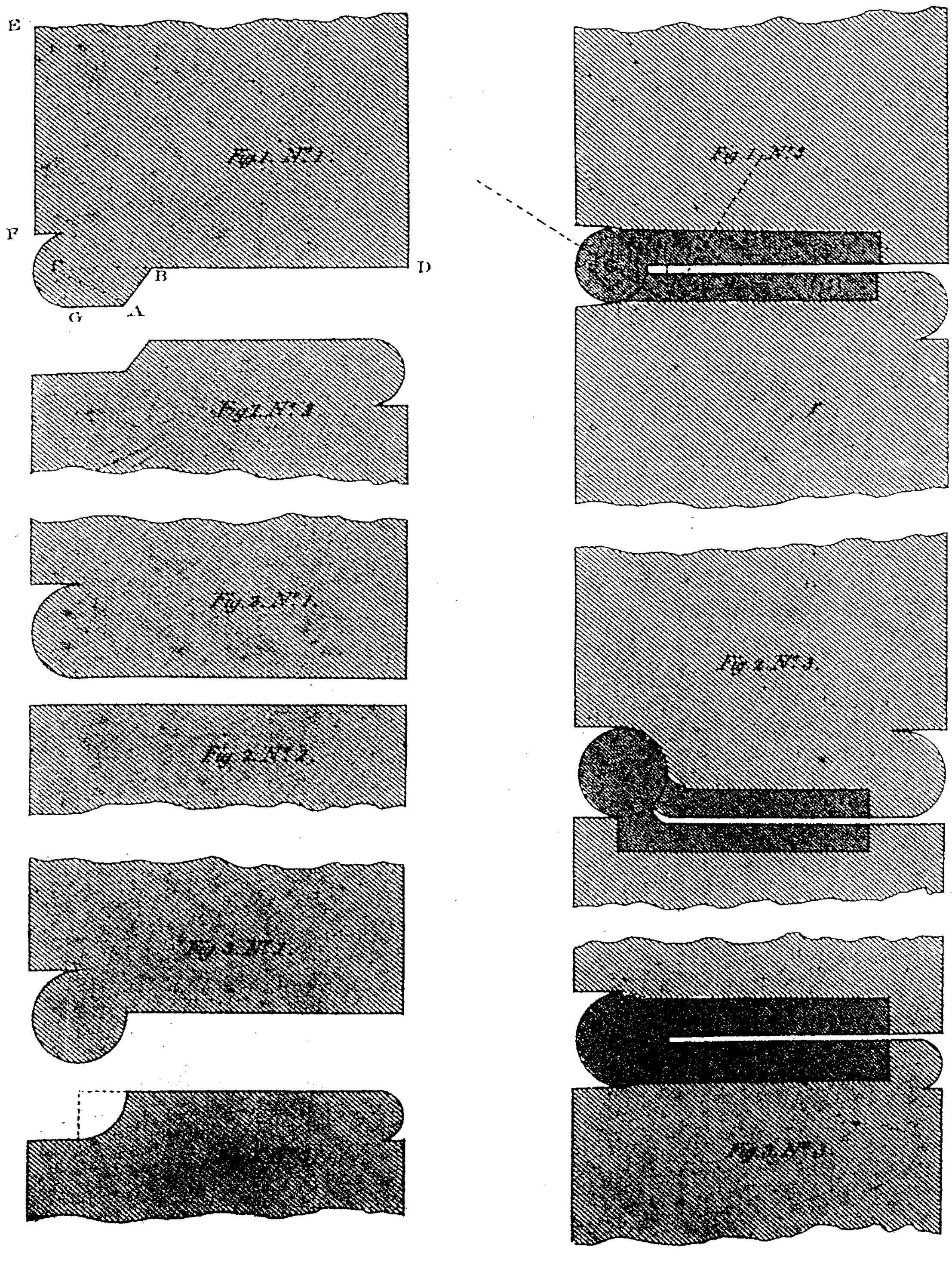

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PLATE XXXI.

OF PLACING HINGES, &c.

How to form the edges or joints of door ſtyles, that are to be hung to each other, ſo that the door may open to a right angle, and ſhow a bead to correſpond exactly to the knuckle of the hinge. Alſo the manner of conſtructing the hinges for the various forms of joints, ſo as to be let in equally upon each ſide.

FIG. 1, No. 1, ſhows the edge of a ſtyle, or it may in ſome caſes be a jamb, on which a bead is conſtructed exactly to the ſize of the knuckle of the hinge, and rabbetted backwards, equal to half the thickneſs of the bead: the manner of conſtructing the rabbet will be ſhown as follows:

Through *C*, the centre of the bead, which muſt alſo be the centre of the hinge, draw *C B D* perpendicular to *E F*; draw *A G* parallel to it, touching the bead at *G*; make *G A* equal to *G C*, the radius of the bead; join *C A*; make *A B* perpendicular to *A C*, cutting *C D* at *B*, then will *G A B D* be the joint required.

No. 2, *fig.* 1, ſhews a part of the hanging ſtyle conſtructed ſo as to receive the edge of No. 1.

No. 3, *fig.* 1, ſhows the above hinged together, with common butt hinges.

Note. It muſt be obſerved in this, and all the following examples of hinges, that the joints are not made to fit exactly cloſe, as there muſt be allowed in working ſufficient ſpace for the paint.

FIG. 2, No. 1, and 2. The manner of conſtructing theſe, being only a plain joint at right angles to the face of the ſtyle, no farther deſcription is neceſſary.

FIG. 2, No. 3, ſhows No. 1, and 2, hinged together, and ſhows the particular conſtruction of the hinge ſo as to be ſeen as a part of the bead, and the ſtrap part of the hinge to be let equally into each ſtyle; this conſtruction of the hinge will admit of a bead of the ſame ſize exactly oppoſite to it.

FIG. 3, No. 1, and No. 2. The manner of conſtructing the edges of ſtyles to be hinged together with common butts, to be let equally into each ſtyle: the manner of conſtructing this joint is ſo plain, by the figure, that it would be uſeleſs to give a deſcription of it. No. 3, the two pieces hinged together.

PLATE

PLATE XXXII.

OF PLACING HINGES, &c.

Methods of jointing styles together so as to prevent seeing through the joints, each side of the styles to finish with beads of the same size exactly opposite to each other, and for the strap part of the hinges to be let in equally into both parts or styles.

FIG. 1, No. 1, and 2, the manner of constructing the joint before hinged together.

FIG. 1, No. 3, shows No. 1, and 2, hinged together with hinges made in the form of common butts.

FIG. 2, No. 1, and 2, shows another method of constructing the joints before hinged together.

No. 3, shows No. 1, and 2, put together, and the particular form of the hinges for the joint.

PLATE XXXIII.

OF PLACING HINGES, &c.

The principle of concealing hinges, showing the manner of making them, and of forming the joint of the hanging style, with the other style connected to it by the hinges, either for doors or windows.

FIG. 1, for a window.

A, inside bead of the sash frame.

B, inside lining.

C, style of the shutter.

Let *a* be the intersection of the face of the shutter, or door, with that of the inside lining of the sash frame.

a r the face of the inside lining.

Bisect the angle *p a r* by the right line *a a*; now the centre *c* being determined in that line, so that the knuckle of the hinge may be at a certain distance from the face *p a* of the shutter; through *c* draw the line *d d*, at right angles to *a a*; then one side of the hinge must come to the line *c d*, the hinge being made as is shewn by the figure.

How

Hingeing.

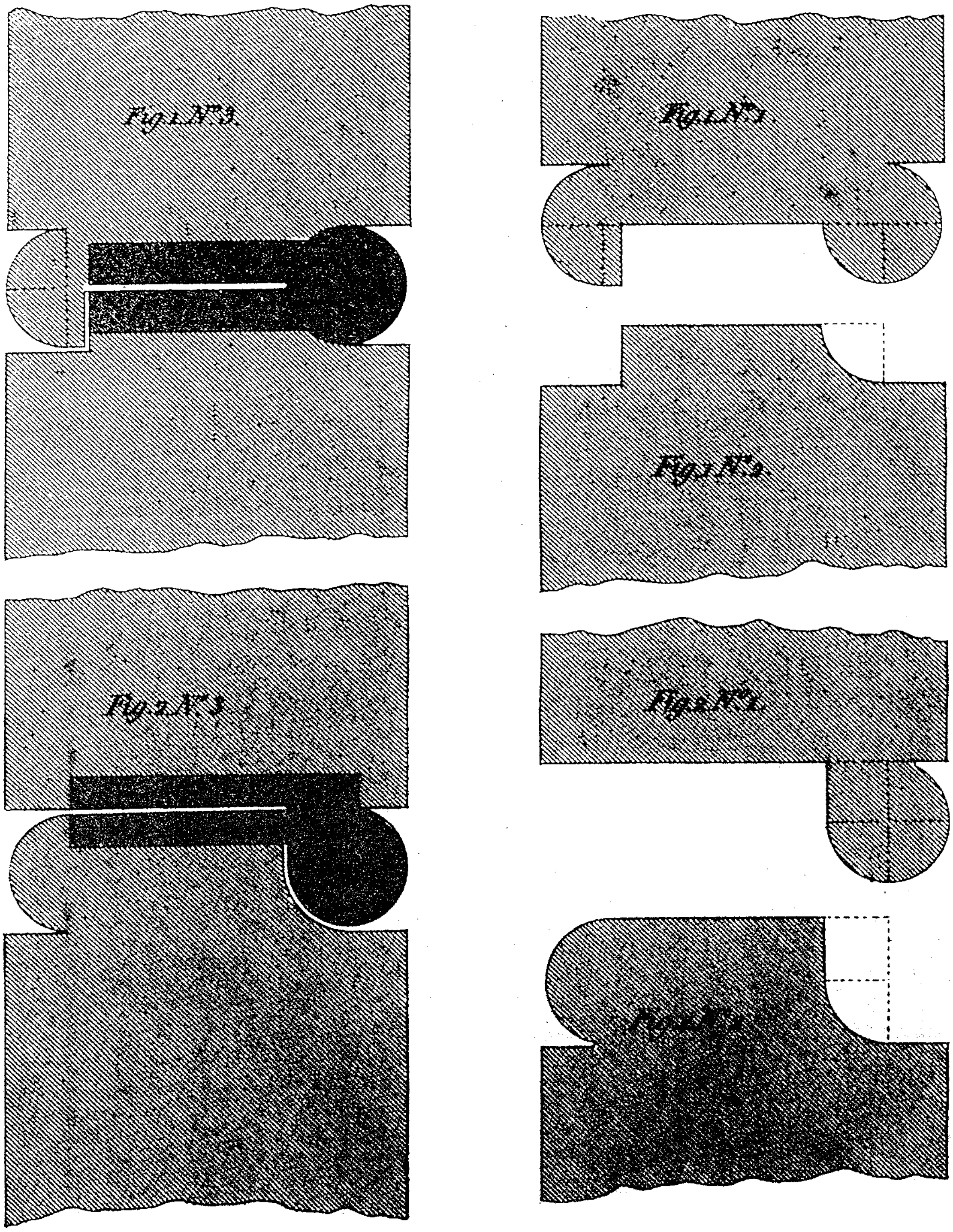

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Fig. 1.

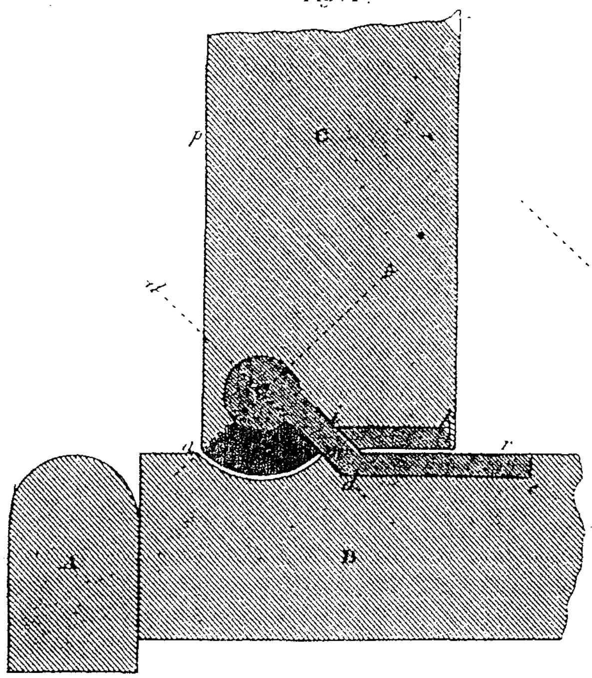


Fig. 2.

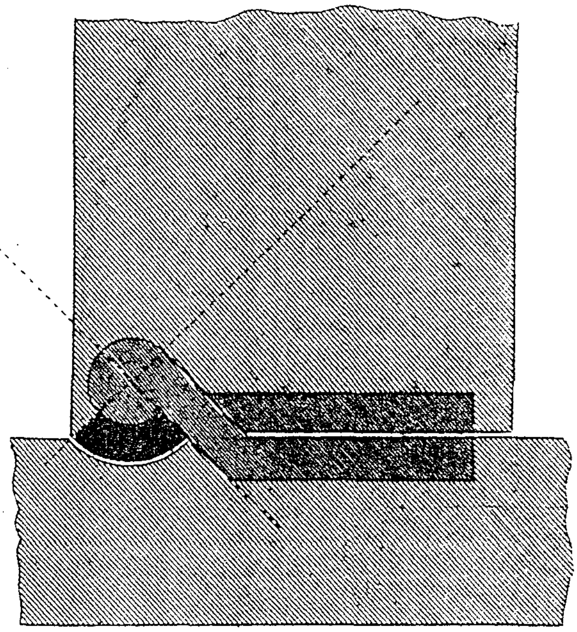


Fig. 3.

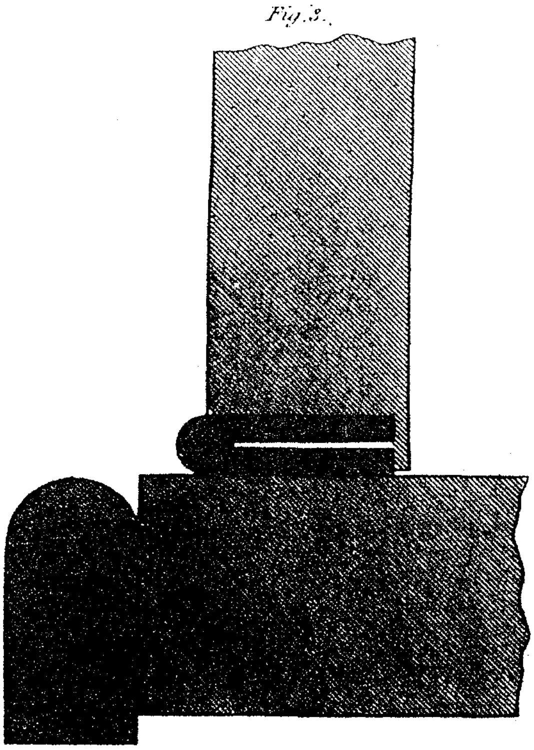
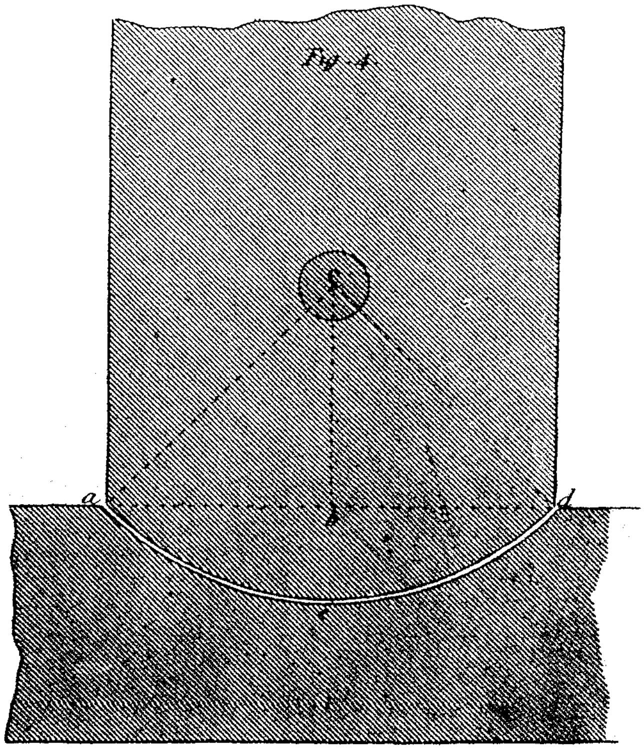


Fig. 4.



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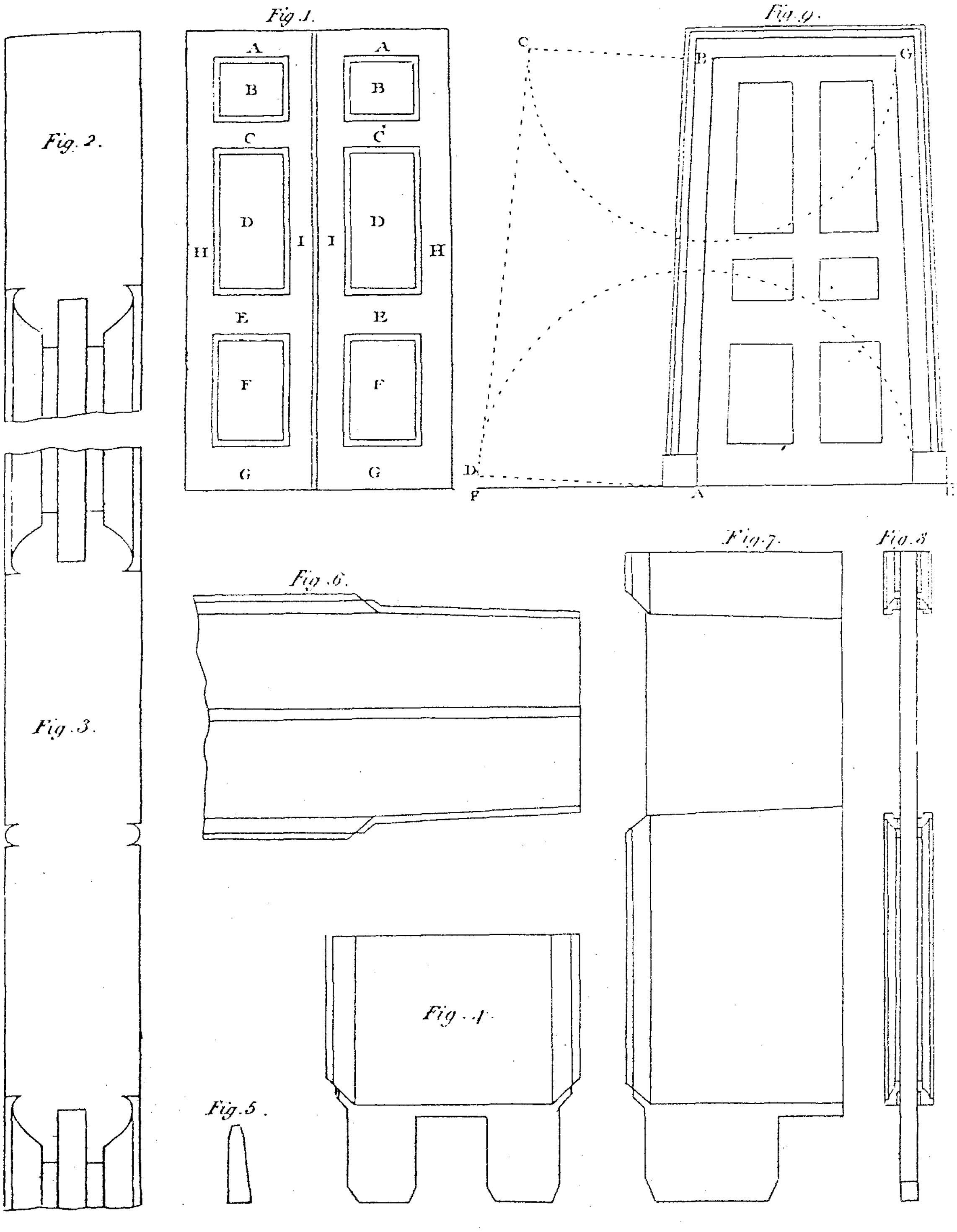

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How to conſtruct the jamb to be clear of the ſhutter.

On *c*, as a centre, with a radius *c a*, deſcribe an arc, *a m*, and it will be the joint required.

Note. When theſe ſort of hinges are uſed in ſhutters, the ſtrap part of the hinge may be made longer on the inſide lining, than that which is connected with the ſhutter.

FIG. 2, is the manner of hanging a door on the ſame principle: the ſhadowed part muſt be cut out, ſo that the other ſtrap of the hinge my revolve; the edge, *c d*, of the hinge, will come into the poſition of the lin [illegible] hen the window is ſhut in.

Here the ſtrap part of the hing [illegible] gths.

FIG. 3, the com [illegible] together, the hinge being let the whole of its thickn [illegible] into the ſaſh frame.

By this mode it is not ſo ſt [illegible] half is let into the ſhutter and half into the ſaſh frame, provided the inſid [illegible] ſufficient thickneſs.

Note. The centre of the hinge in this muſt be in the ſame plane with the face of the ſhutter, or beyond it, but not within the thickneſs.

FIG. 4, the method of hanging a door with centres. Let *a d* be the thickneſs of the door, and biſect it in *b*; draw *b c* perpendicular to *a b*; make *b c* equal to *b a*, or *b d*; on *c* (the centre of the hinge) with a radius *c a*, or *c d*, deſcribe an arc; *a e d* will give the true joint for the edge of the door to revolve in.

PLATE XXXIV.

OF DOORS.

The method for making double margin doors.

FIG. 1, *A*, *A*, top rails.
B, *B*, top, or frize pannels.
C, *C*, frize rails.
D, *D*, middle pannels.
E, *E*, Lock, or middle rail.
F, *F*, bottom pannels.
G, *G*, bottom rails.
H, *H*, outſide ſtyles.
I, *I*, middle ſtyle, ſhowing two ſtyles.

This door is a kind of deception for a pair of folding doors; it is frequently uſed for an outſide door, where the door is wanted to open all on one ſide.

In

In order that this ſort of door may appear a complete deception, there will be ſome difficulty in making and putting on the furniture; to accompliſh this, the lock may be conſtructed with a long bar, or rod, to reach from one of the middle ſtyles to the jamb; and the rail itſelf may be glued up hollow, ſo that the bar of the lock, and bolts, may work as eaſy as poſſible.

FIG. 2, ſection of the ſtyle *HH*, with part of the plan of one of the rails.

FIG. 3, ſection of the middle ſtyle; this and *fig.* 2, are ſhown to a larger ſcale than the following.

FIG. 4, part of the lock rail, ſhowing the double tenon which goes into the ſtyle.

FIG. 5, one of the wedges that wedges the ſtyles and rails together.

FIG. 6, part of the middle ſtyle, ſhowing the tenon which goes into the bottom rail, *fig.* 7: this tenon is made double.

FIG. 7, part of the bottom rail, ſhowing how it is made to receive the middle ſtyle.

FIG. 8, the thickneſs of *fig.* 7, ſhowing the wood that is left in the middle to receive the tenon of *fig.* 6.

To find how far a door made in the manner of fig. 9, *will clear the floor, when opened to a right angle.*

FIG. 9. Make the angle *B A D*, equal to the angle *B A E*; make *A D* equal to *A E*; alſo make the angle *A B C* equal to the angle *A B G*, and make *B C* equal to *B G*; join *D C*; then will *A B C D* be the true poſition of the door.

And the angle *D A F*, will be double the angle that the bottom of the door will make with the floor, when it is opened to a right angle.

OF HANGING DOORS.

Having treated thus fully on the various kinds of hinges adapted to ſundry purpoſes, before I conclude the ſubject, it may be proper to make a few obſervations upon, and to give ſome rules for, hanging of doors, ſo as to clear the ground or carpet.

1ſt. Raiſe the floor under the door as much as may be neceſſary, according to the thickneſs of the carpet, &c.

2d. Make the knuckle of the bottom hinge to project beyond the perpendicular of the top hinge about one-eight of an inch, this will throw the door off the floor.

Note. The centre of the top hinge muſt project a little beyond the ſurface of the door, if the hinge is let equally into the door and into the jamb; otherwiſe, if the centre lay in the ſurface of the door, it ought to be placed at the very top, which is ſeldom done.

3d. Fix the jamb, on which the door hangs, away from the plumb-line, ſo that the top of the jamb may incline to the oppoſite jamb about one-eight part of an inch, this will have the effect to clear the door off the floor.

4th. Make the door, when ſhut, to project at the bottom towards the inſide of the room, about one-eighth of an inch, which may be effected by giving the rabbet the quantity of inclination requiſite.

Note

Note.—Although any of the above methods properly applied will make a door fwing fufficiently clear of the floor, yet as each one feparately will require to be done in fo great a degree as to offend the eye, I do not recommend them in nice work, but would rather advife a combination of them all to be ufed, thus:

Raife the floor about one-eight of an inch under the door; make the jamb on which the door hangs incline to the oppofite jamb about one-eighth of an inch; make each rabbet that ftops the door project at the bottom one-eighth of an inch to that fide of the room on which the door opens. Now thefe feveral methods practifed in the above fmall degrees, which will not be perceptible, will throw the door fufficiently out of the level when opened to a fquare; that is, it will be at leaft half an inch when the height of the door is double its width. Again,

5th. An invention has lately been introduced called *Rifing Hinges*, which are made with a fpiral groove winding round the knuckle; but as this method introduces an error in workmanfhip, I cannot well recommend it, for the door ought to be clofe fitted in, except fufficient room for the painting (for which workmen ufually allow a fpace the thicknefs of a half crown), and as the door is continually rifing on the fpiral groove, it will be neceffary either to cut away part of the hanging ftyle at top, or elfe to cut the foffit to allow room for the door to rife on the hinge; this, when the door is fhut, has an aukward and unworkman-like appearance.

6th. This purpofe would be completely anfwered by adopting a door in the form of the antique doors; that is, the bottom to be wider than the top, the jambs having the fame inclination. This figure is introduced, not for the purpofe of its being adopted in general ufes, though it will clear the ground fufficiently, and it will fall to of itfelf; its properties are,

FIG. 9. Make the angle *B A D* equal to the angle *B A E*; make *A D* equal to *A E*; alfo make the angle *A B C* equal to *A B G*, and make *B C* equal to *B G*, join *D C*; then will *A B C D* be the true pofition of the door when folded back, and the angle *D A F* will be double the angle that the bottom of the door will make with the floor when it is opened to a right angle.

7th. For common or ordinary purpofes, fuch as warehoufe or fhop doors, &c. the following eafy method is ufeful, as it will fufficiently clear the ground, and the door will always fall to of itfelf.

The top hinge may be a common butt hinge, the bottom one muft have a knee to project out, thefe hinges muft be placed in fuch a manner, as that a line drawn through their axis fhall touch the door at the top and cut the floor beyond the furface of the door an inch and a half or more, according to circumftances.

There is another kind of hinge which is applicable to gates or rough work; the upper hinge may be of the common conftruction, but the lower one is made with a circular knee, and is fixed in the partition out of the plane of the joint of the door; the axis of the hinges, as in the former cafe, muft be in a line with the top of the door, gate, &c.

PLATE XXXV.

OF DOORS.

How to find the true bevel for hanging any door.

FIG. 1. Let *a* be the centre of the hinge; on the width of the door *a b* defcribe a femicircle *b c e d a*, cutting the other fide of the door at *c* and *d*. Join *a d* and *b c*, which will be the proper edges of the door, in order to make it open freely.

Note.—The bevelling on the fide *a d* is of no other confequence than to make the fides uniform.

How to find the joint for a pair of folding doors.

FIG. 2. Let *h* and *g* be the centre of each hinge; bifect *h g* by a perpendicular *a b*, cutting the thicknefs of the door at *a* and *b*; bifect *a b* by the perpendicular *c d* at *e*; make *e c* and *e d* each equal to half the thicknefs that you intend the rabbet to be. Suppofe you intended the flap *g a c d f* to open; draw a line from *d* to the centre of the hinge at *g*; on *d g* defcribe a femicircle *d f i g*, cutting the other fide of the door at *f*; join *f d*, and through *c* draw *c k* parallel to it; then *k c d f* will be the proper joint.

Note.—If you put a bead at the joint, it ought to be exactly in the middle of the door.

PLATE XXXVI.

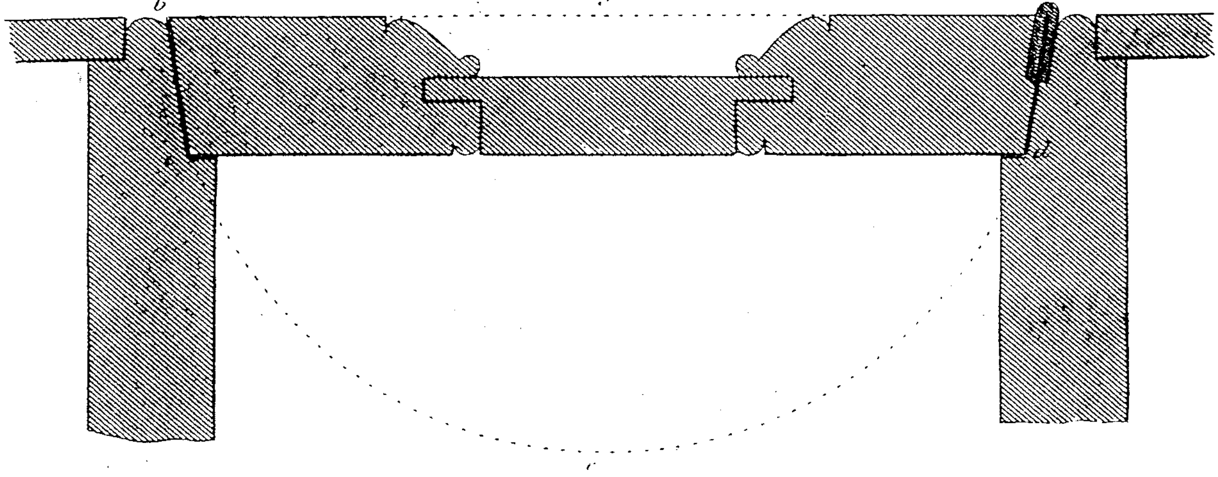
OF DOORS.

How to find the bevel on the edge of a door when it is executed on a circular plan, and the door to turn out on the convex fide of the circle.

With regard to the circular door, *fig.* 1, all that is required is to make the angle *a b c* either a right angle or greater than a right angle (for a right angle is the leaft that any door will admit of) formed by the edge of the door, and a line drawn from the centre of the hinge to the oppofite angle.

For the folding doors.

FIG. 2. Let *a* and *b* be the centres of the hinges on the plane; join the points *a* and *b* by the right line *a b* and bifect it by a perpendicular *c d e* at *c*, cutting the thicknefs of the



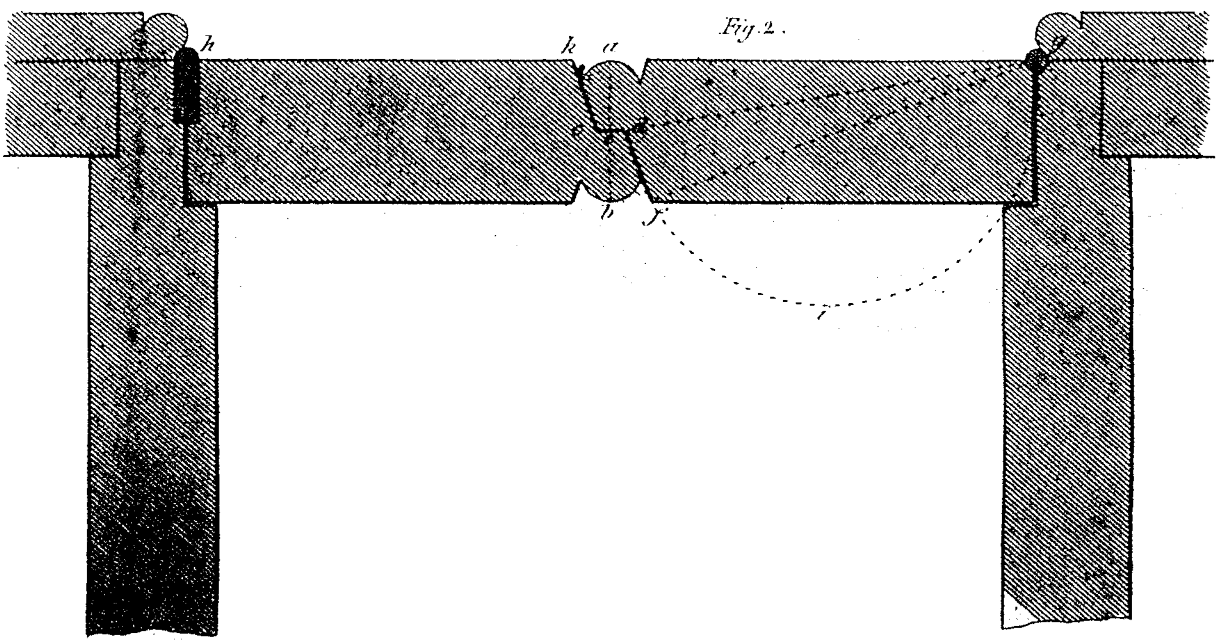


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Fig. 1.

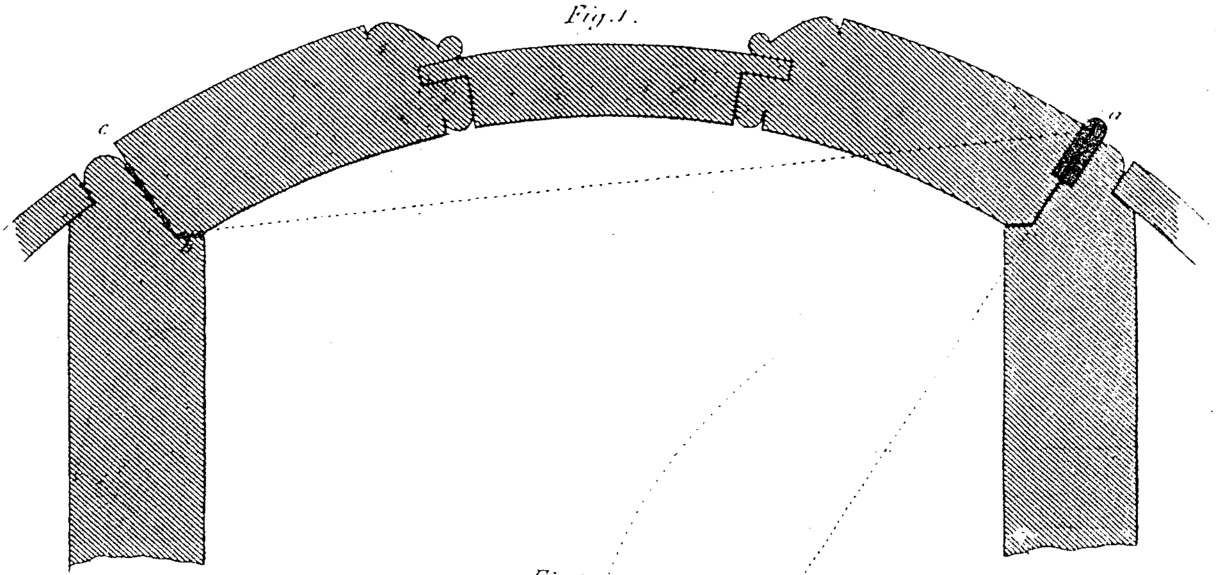

Fig. 2.

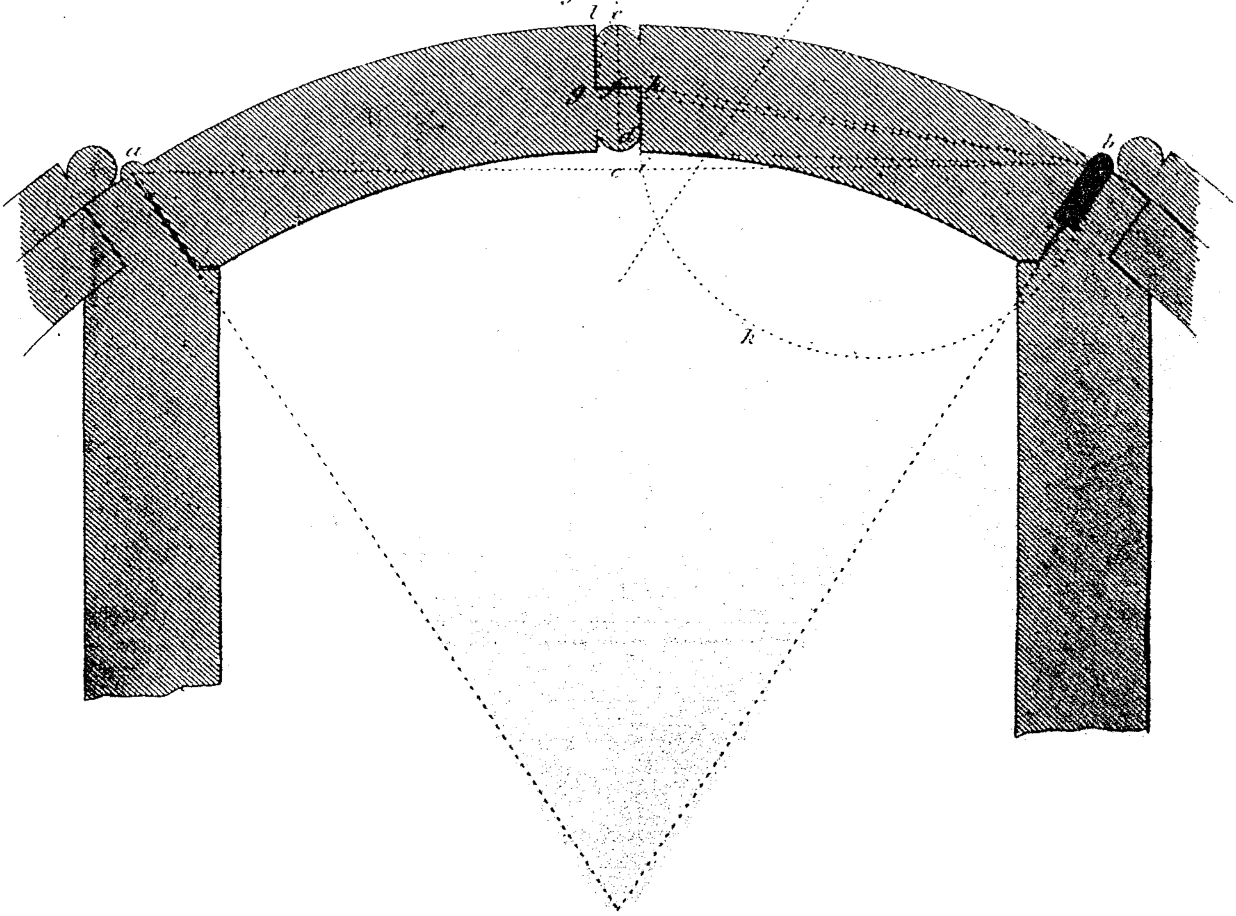

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Fig. 1.

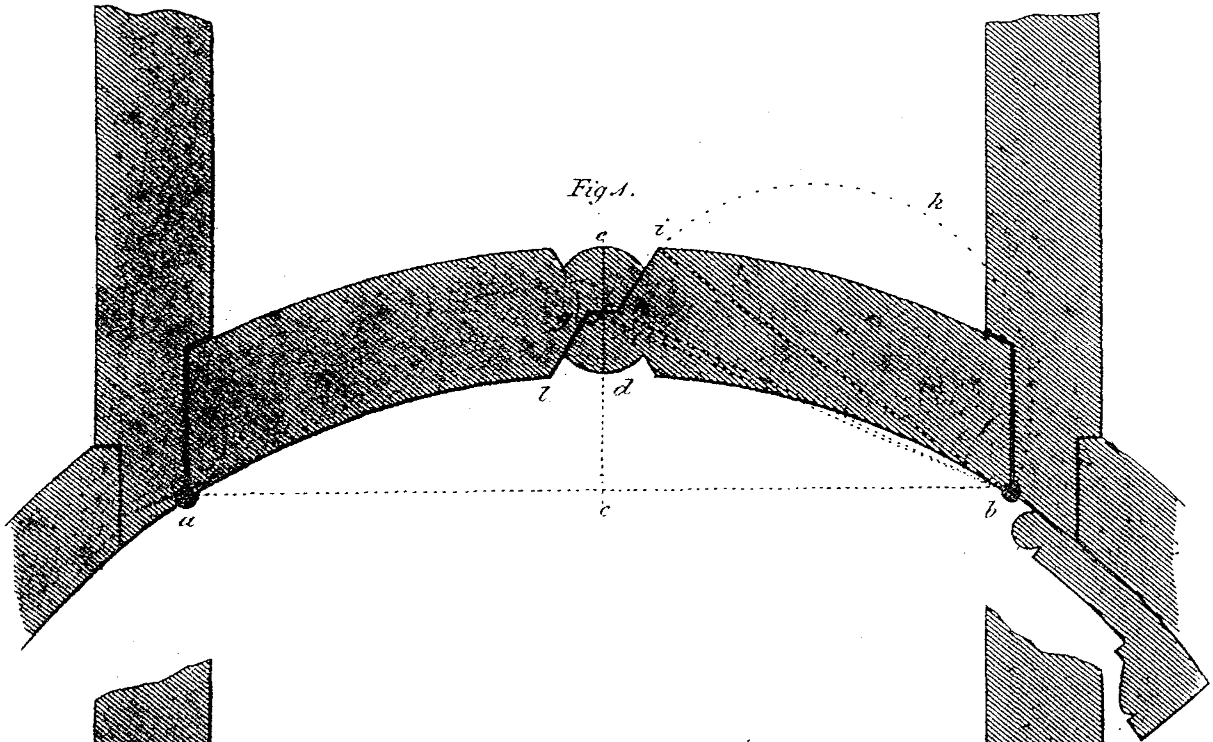
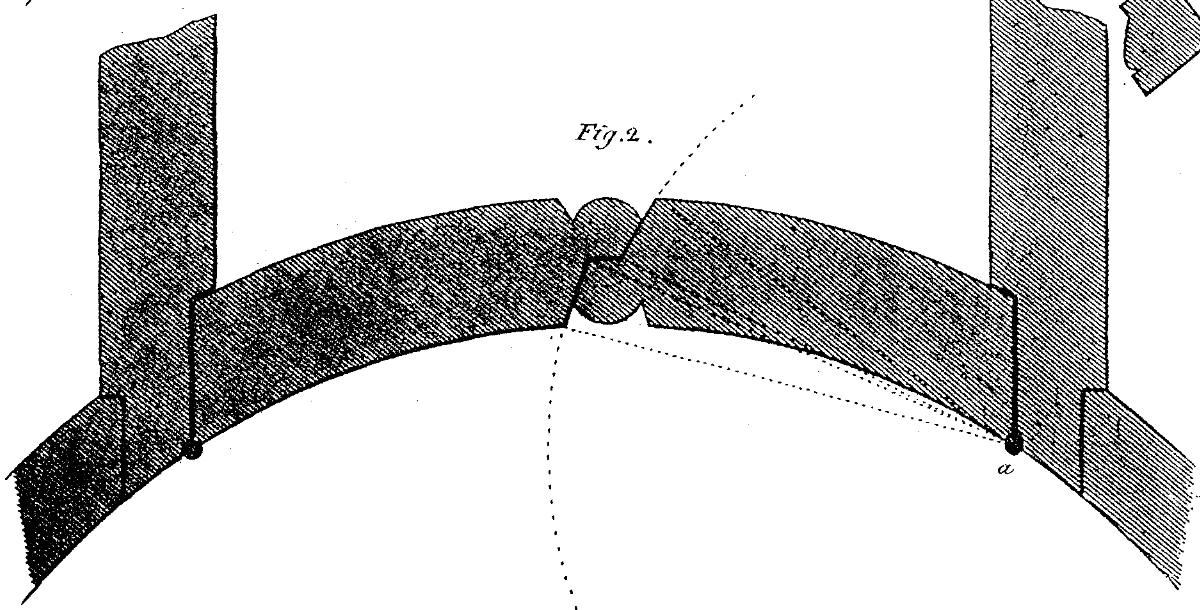


Fig. 2.



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the door in *d* and *e*; biſect *d e* by a perpendicular *g f h* at *f*; make *f h* and *f g* each equal to half the thickneſs of the rabbet; join *h b*; on it deſcribe the ſemicircle *h i k b*, cutting the other ſide of the door contrary to the knuckle of the hinge at *i*; join *i h* through *g*; draw *g l* parallel to it; then will *l g h i* be the proper joint for the meeting of the two doors.

PLATE XXXVII.

OF DOORS.

How to find the meeting joint of folding doors when the hinges are placed on the concave ſide of the door.

FIG. 1. Let *a* and *b* be the centres of the hinges; join *a b* and biſect it by a perpendicular *c d e* at *c*, cutting the thickneſs of the door at *d* and *e*; biſect *d e* by a perpendicular *g f h*, cutting *d e* at *f*; make *f h* and *f g* each equal to half the thickneſs of the rabbet; join *b h*; on it deſcribe a ſemicircle *h i k b*, cutting the other ſide of the door contrary to the hinge at *i*; join *i h*, and through *g* draw *g l* parallel to it, cutting the concave ſide of the door at *l*; then will *i h g l* be the joint ſought.

Demonſtration.

Let the door *a l g h i* remain in its place; now the angle *b i h* being a right angle, conſequently the perpendicular *b i* will be the ſhorteſt line that can be drawn from the point *b* to the line *I H*; now let the half door be turned round the hinge at *b*; the point *i* will then deſcribe a circle whoſe centre is the hinge at *b*; then will *i h* be a tangent to that circle at *i*; therefore the angle at *i* will touch no other part of *i h*, that is, the edge of the other door, but at *i*.

If round the centre of that door that opens, as *fig.* 2, you deſcribe circles on each ſide of the rabbet, and the edges of each door be made circular, it is plain it will alſo open in this caſe.

PLATE XXXVIII.

OF DOORS.

Elevation and section of a pair of folding doors to open a communication between two rooms, or to make two rooms into one upon any occasion.

FIG. 1, the elevation of the folding doors.

a b c d, and *A B C D*, hanging styles hung to the jambs at *a b* and *A B*.

c d e f, and *C D e f*, the two doors hung to the hanging styles at *c d* and *C D*; the shadowed parts denote the hinges.

FIG. 2, the plan or rather a horizontal section.

The several parts of this door are shown at large in the next plate.

On one side of this plate the hanging style is pannelled, and on the other side it is reeded. The former will be proper when the hanging style is very wide, and the latter when it is very narrow.

PLATE XXXIX.

OF DOORS.

Horizontal sections of the foregoing plate, showing completely how the different parts of the work are connected with each other.

FIG. 1, a section of the jamb post.

B, *b*, sections of the grounds flush or in the same plane with the plaister.

E, *e*, outside and inside architraves.

g g g, line of the plinth.

G, jamb lining.

H, hanging style.

I, style hung to the hanging style *H*, by means of the hinge *m*.

FIG. 2, half of the plan, *fig.* 1, showing the door folded back; the parts in *fig.* 2, have the same references as *fig.* 1.

FIG. 3, the joint or hinge at *m* in *fig.* 1, with part of the style hinged together to a large size.

FIG. 4 and 5, shows how the joint must be made before hinged together.

FIG.

Fig. 1.

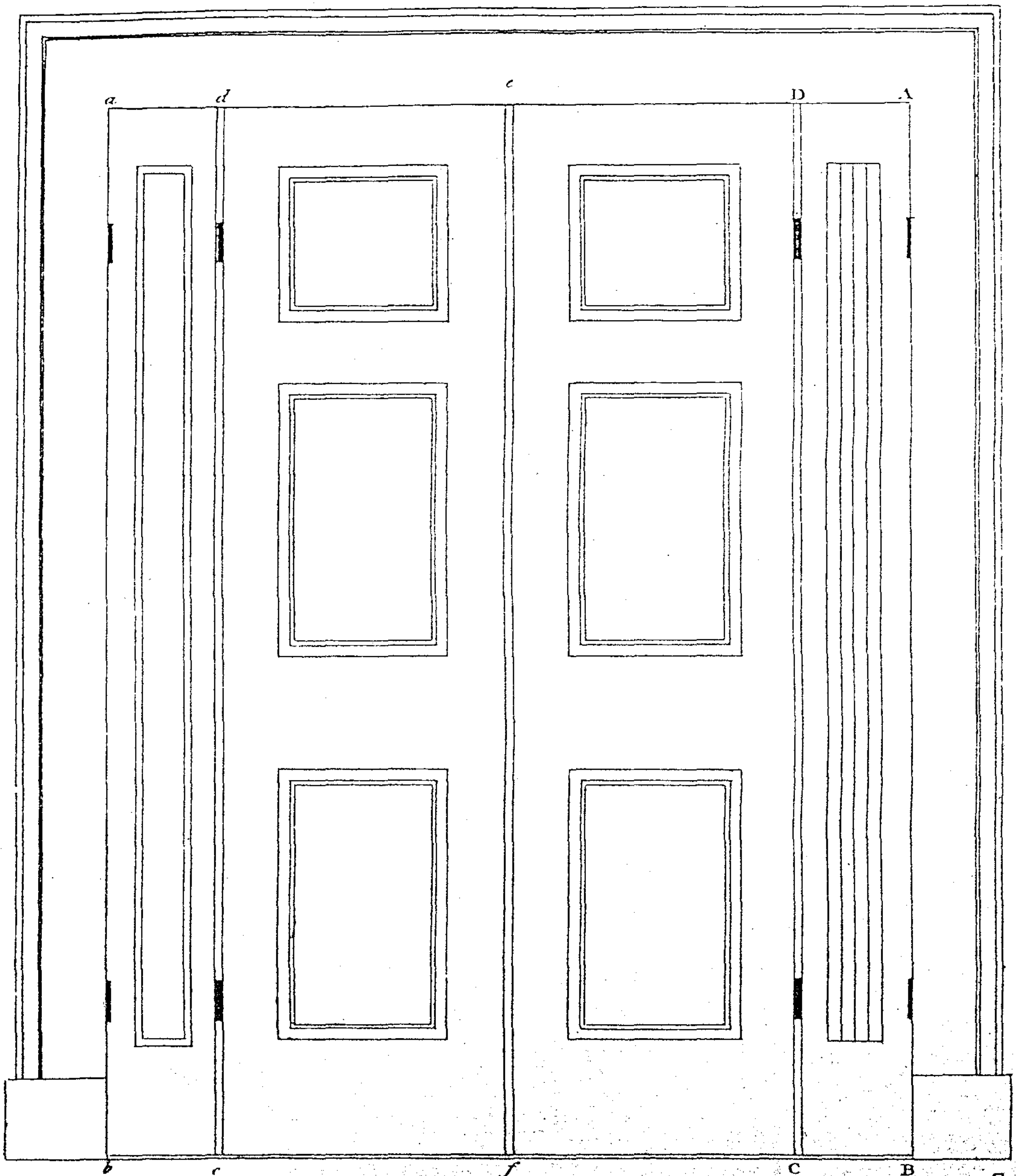
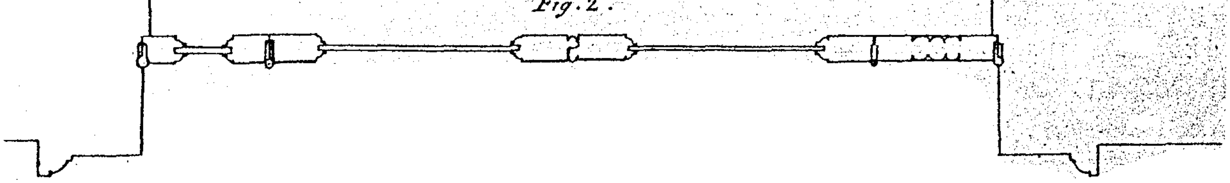


Fig. 2.



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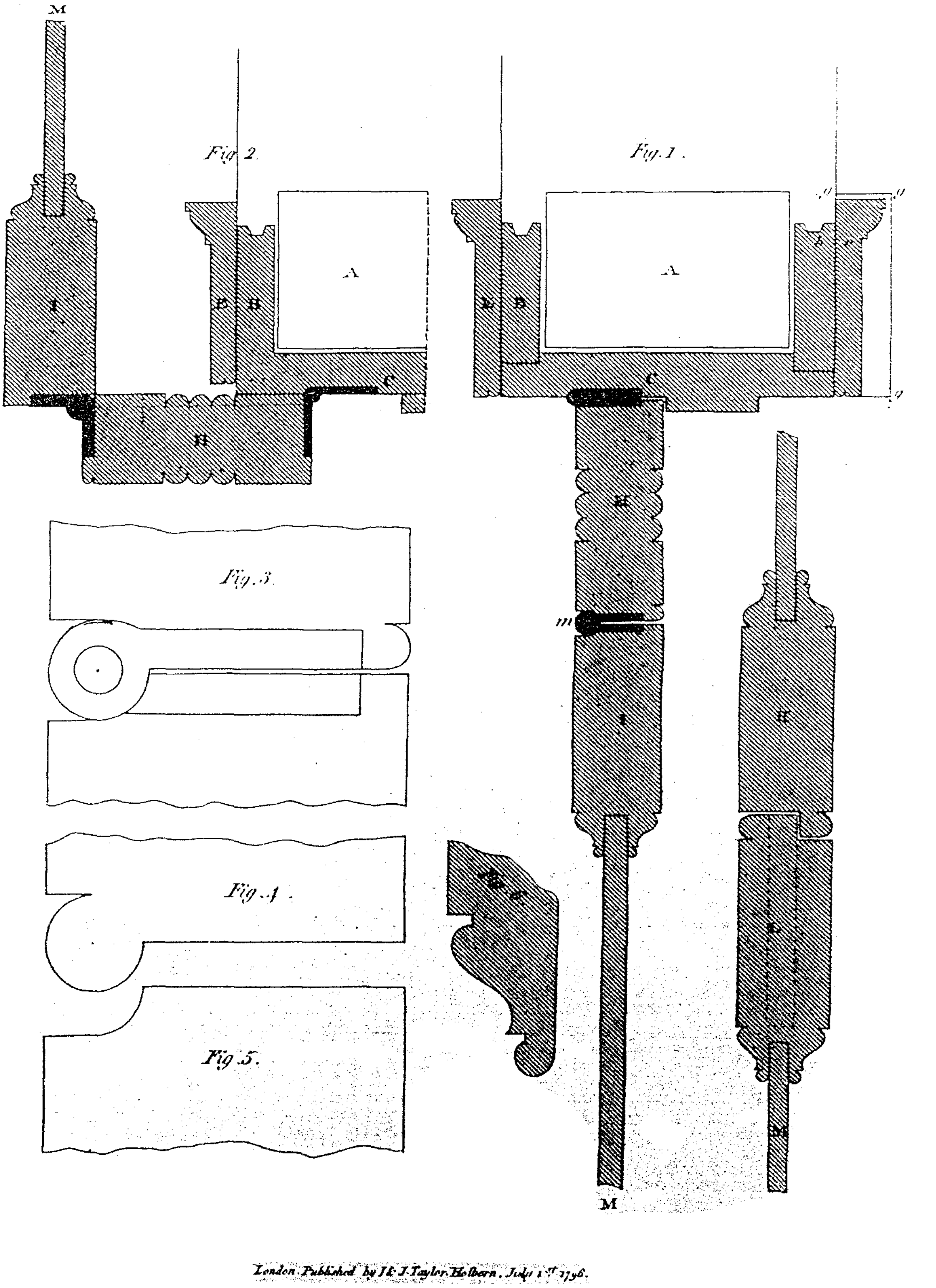

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Fig. 1

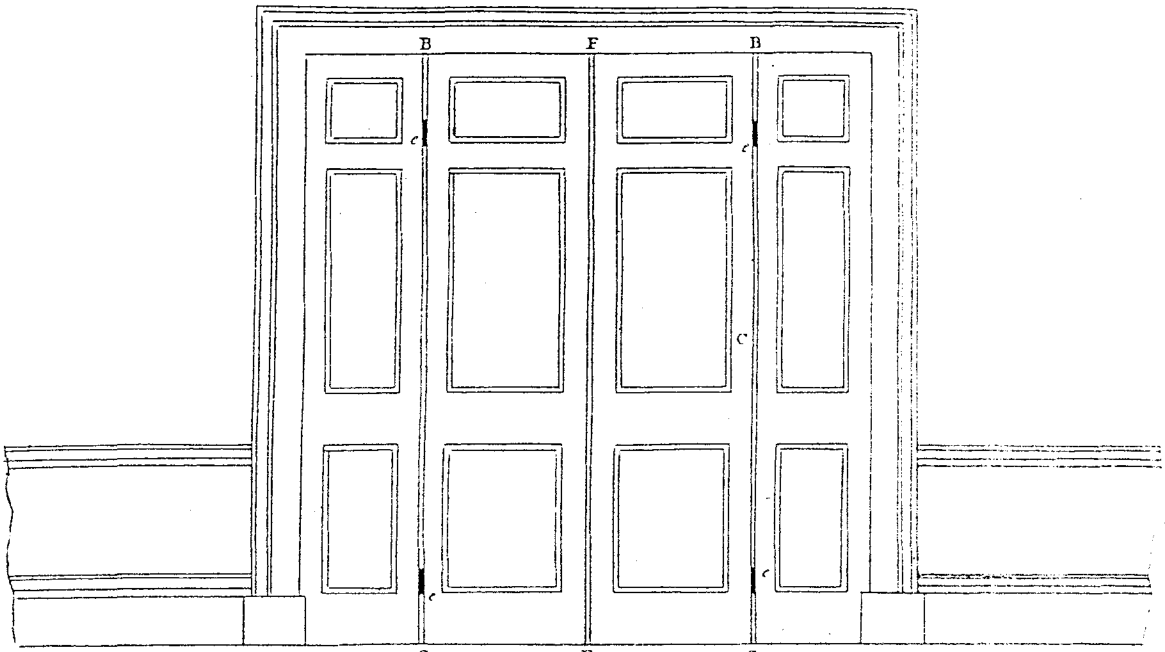

Fig. 2

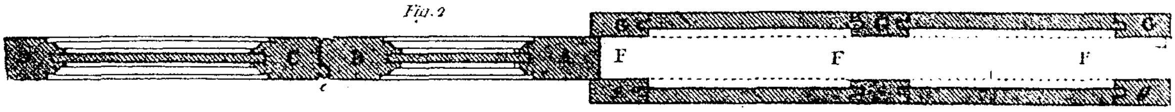

Fig. 3

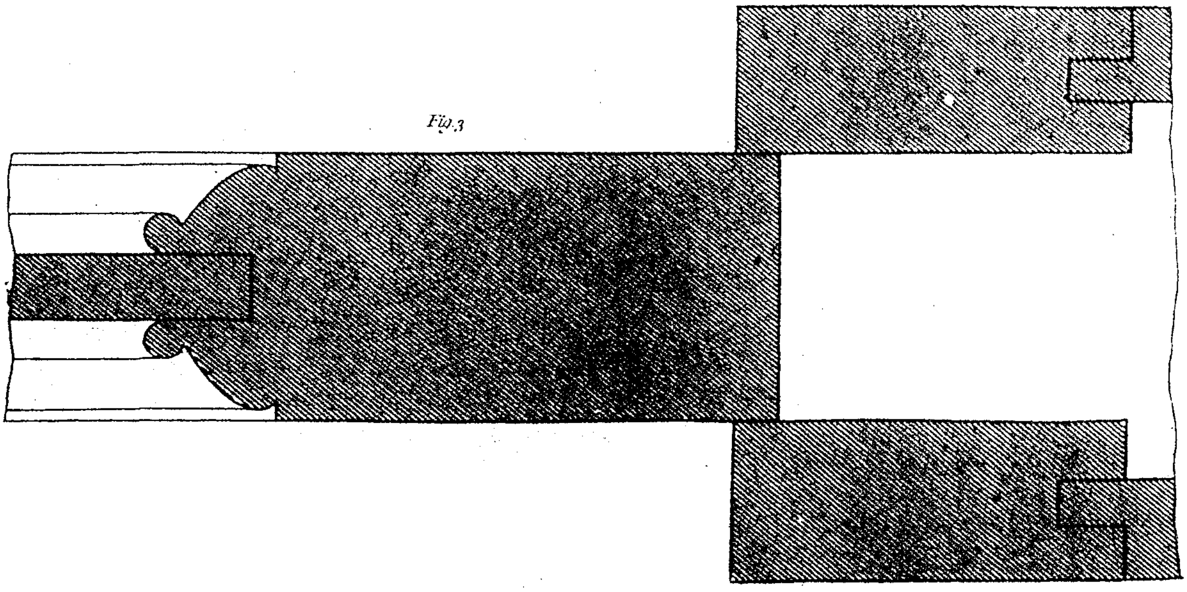

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FIG. 6, the moulding of the door ſhown to a larger ſize.

This method is adviſeable where you have no opportunity of making the doors ſlide into the partition, as is ſhown in plate 40; but whenever that opportunity offers I ſhould prefer it, as no door can be ſeen when ſhut into the partition, which not only keeps them entirely out of the way, but makes the moſt complete appearance.

PLATE XL.

OF DOORS.

Elevation of a pair of folding doors to be ſhut quite out of the way, in order to open a communication between two rooms, or to throw both into one on any occaſion.

FIG. 1, elevation of the door.

FIG. 2, plan of half the door to double the ſize of *fig.* 1.

A, plan of the outſide ſtyle.

B and *C*, plans of the hanging ſtyles.

D, one of the metting ſtyles.

G G G, and *g g g*, framed partitions diſtant from each other, in the clear, the thickneſs of the door.

F F F, the ſpace or cavity for the door to work in, which muſt be made ſufficiently wide to receive one half the door entirely within, or nearly ſo; doors of communication for general uſes may be conſtructed in this larger door, in which caſe the middle pannels or doors may be hung to the others, at *e, e, e, e,* ſo that they will open like any other common folding door; this method therefore combines utility and convenience, and is a complete deception. The firſt leaf of the door, *A B*, *fig.* 2, muſt run in a groove at the top to make it ſteady.

The manner of making and hanging the joints *B C*, *fig.* 1, are already ſhown in plate 32, *fig.* 2, No. 1.

FIG. 3, a ſection of the ſtyle next to the partition to a larger ſize, with part of the plan of the bottom rail, ſhowing a ſmall part of each partition.

Note.—In ſetting out work of this kind for practice, one half of the plan ought to be completely drawn out.

PLATE

PLATE XLI.

OF DOORS.

The elevation of a Jib door; that is, a door which has the ſame finiſhings and appearance as the room in which it is placed, ſo that it may be known to be a door as little as poſſible.

FIG. 1, the elevation of the door, ſhewing the baſe and ſurbaſe mouldings of the other parts of the room. The top part of the door may be fluſh framing, which will be covered with paper as the other parts of the room. The bottom part, as in general, lined with half-inch ſtuff, running in the ſame direction as the dado, in order to ſhow a continuation of the dado; afterwards the baſe and ſurbaſe moulding are fixed.

FIG. 2, the plan of the door.

A, the thickneſs of the baſe moulding.

B, the thickneſs of the lining.

C, the thickneſs of the pannel.

D, the lock ſtyle.

E, the mountain.

F, the hanging ſtyle.

FIG. 3, the ſurbaſe moulding to a larger ſize.

FIG. 4, the baſe moulding to a larger ſize.

The manner of hanging a door of this conſtruction will be ſhewn in the following plates.

PLATE XLII.

OF DOORS.

The manner of conſtructing the baſe moulding of a Jib door by a circular motion in the joint.

FIG. 1, the elevation of the moulding.

FIG. 2, ſection of the door and jamb.

From *A*, the centre of the hinge, draw *AB* perpendicular to the face of the door; make *AB* equal to the projection of the ſurbaſe moulding in *fig.* 1. Make all the projections

Ag,

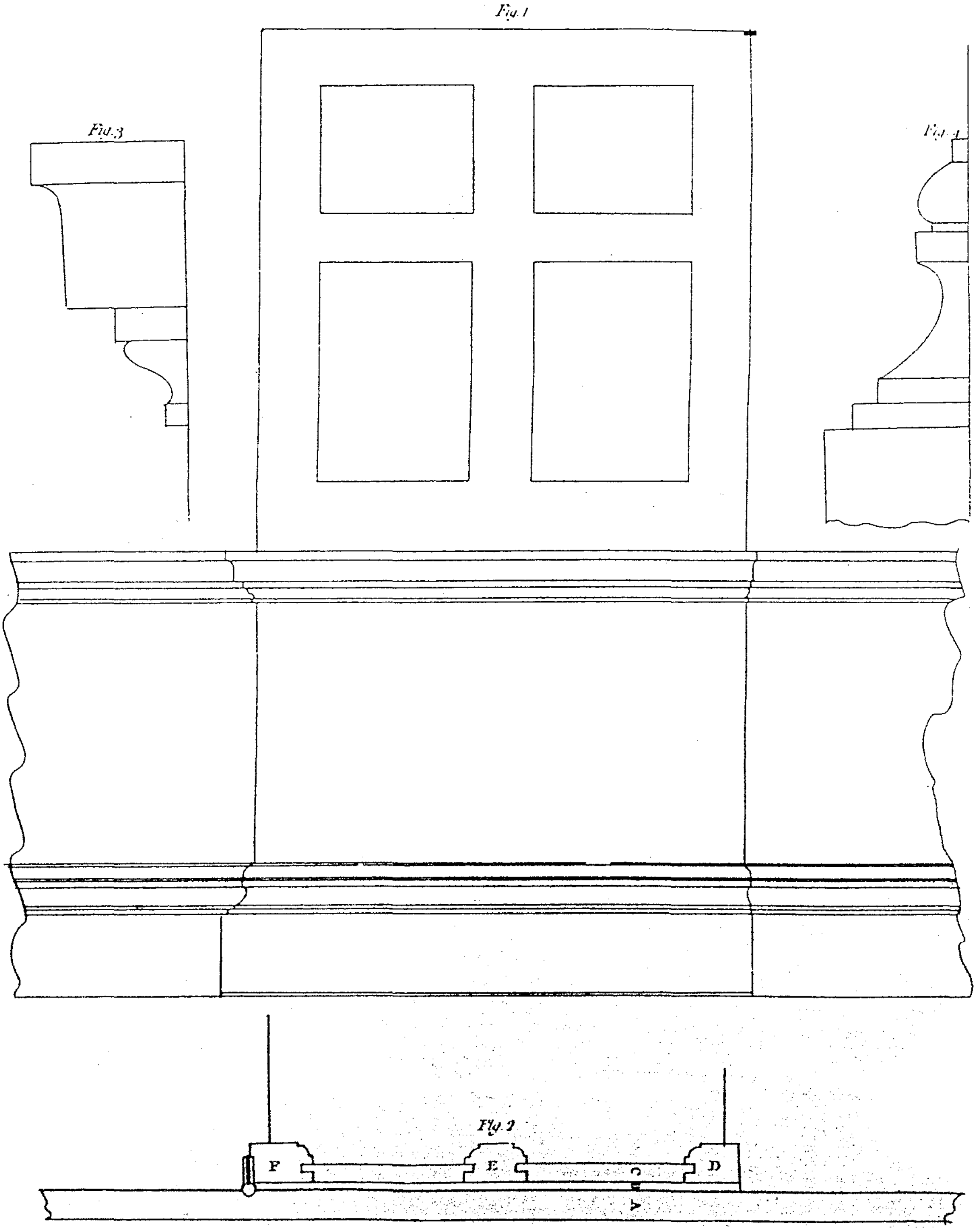

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Fig.1.

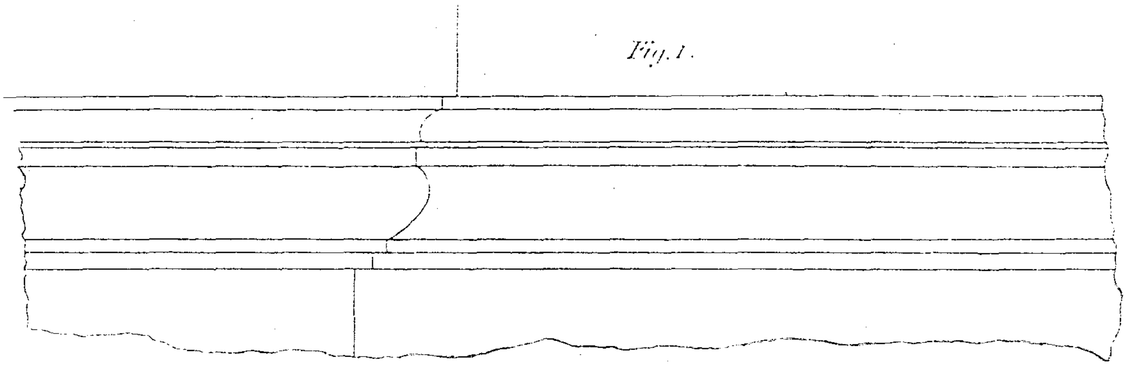


Fig.2.

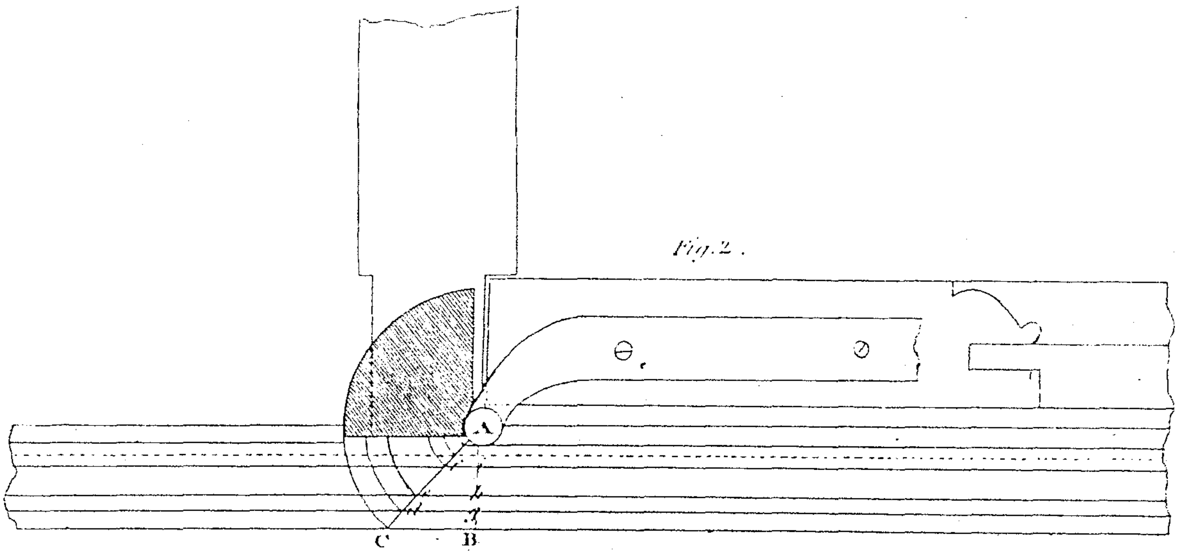
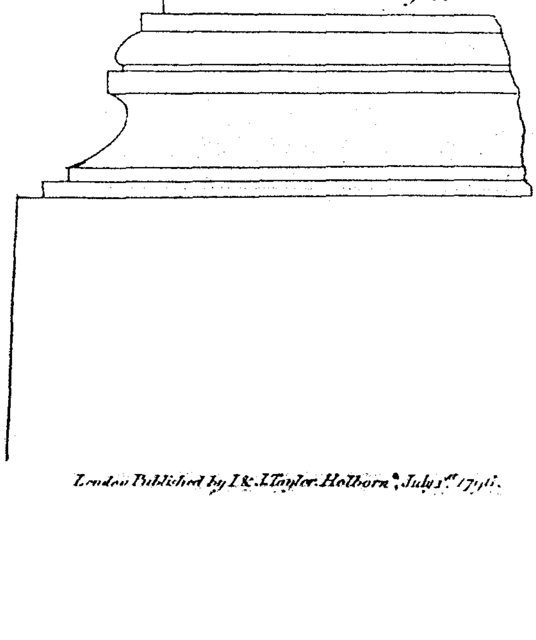


Fig.3.



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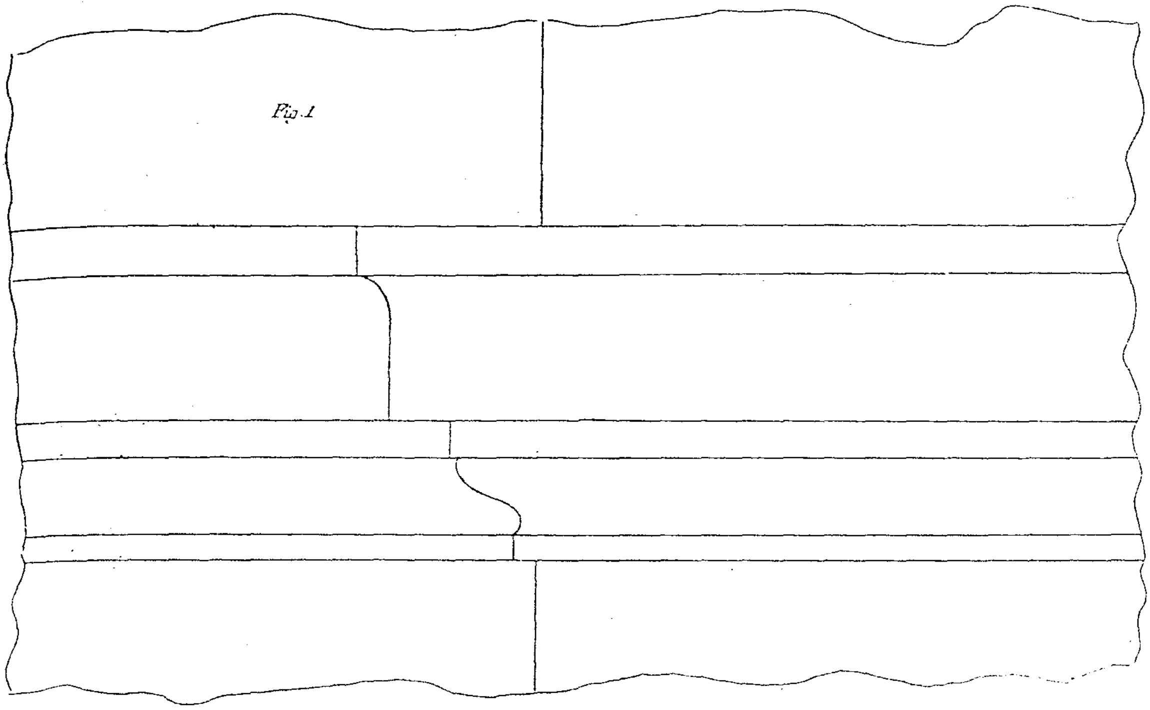

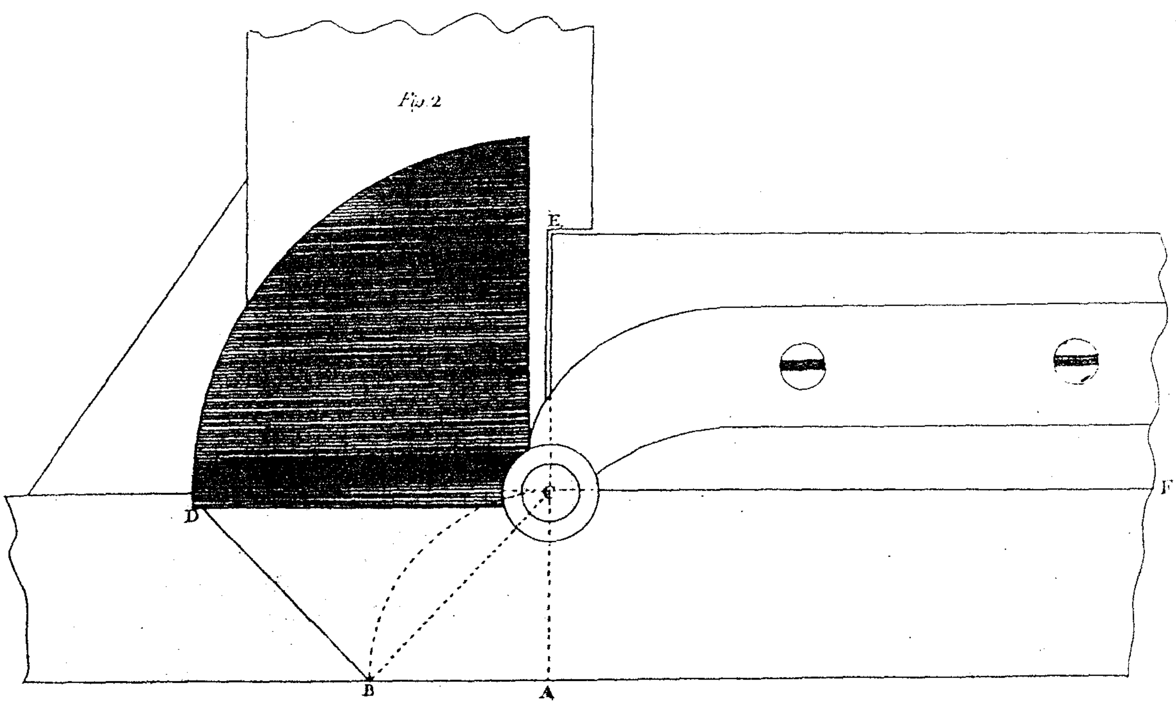

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$A g$, $A h$, and $A i$, equal to all the projections of the fillets in *fig.* 1; through the points B, g, h, i, draw parallel lines; make $B C$ equal to the projection $A B$, and join $A C$ cutting the parallel lines at d, e, f; then from the centre A with the radii $A d$, $A e$, and $A f$, describe arcs $d k$, $e l$, and $f m$, for the joint of each fillet, and the jamb must be cut out to fit these joints; but there must be about one-sixteenth part of an inch left whole on that edge next to the door; and since the door describes one quarter of a circle, there must also be one-sixteenth part of an inch cut out of the base moulding; this will appear a small defect when the door is shut, because it will appear open where it is cut away in the surbase; but not being more than one-sixteenth part of an inch, will nearly be covered by the paper.

FIG. 3, shows the projections of the mouldings along the diagonal $A c$, which is to be applied on the back of the surbase moulding, in order to be a guide to work it out circular on the back.

PLATE XLIII.

OF DOORS.

How to find the joint of a Jib door, so that it shall open freely at the hanging side, and the joint to be a plane.

FIG. 2. Let C, the centre of the hinge, be in the same plane with the dado, and also with the joint $C E$.

$C E$, the thickness of the door at the joint, which produce till it cut the opposite side of the base moulding at A; make $A B$ equal to $A C$; join $B C$, and from B draw $B D$ perpendicular to $B C$; then will $B D$ be the true line on which the surbase moulding must be cut perpendicular to the floor. The shadowed part shows a part of the jamb lining cut out sufficient to let the surbase moulding move in it.

Note.—The jamb lining must not be cut quite through, but there must be a small substance of wood remaining, otherwise the whole cavity of the door will show when it is open.

Also remember to put a blocking in the interior angle opposite to the hollow part, which is cut out in order to let the the surbase moulding move in it, if the thickness of the jamb lining is not sufficient.

The bottom part of the door may revolve on a centre or pivot in the floor, by this means the centre will be quite concealed.

The upper part may be hung with butt hinges, and the centre of the hinge must be in the same plane with the face of the door, so the joint upon the hanging side will always be close.

FIG. 1, the elevation of the joint.

PLATE

PLATE XLIV.

OF DOORS.

How to hang folding doors so that each door shall open or shut together, called Sympathetic Doors.

FIG. 1, the lower part of the folding doors, showing two cranks under the floor; *c c* shows the centres of the cranks; the two cranks are connected together by means of a rod *A A*.

FIG. 2, the plan of the cranks; *c c* their centres; *A A* the rod fixed to each crank as in the elevation, *fig.* 1.

How to find the position of the cranks so that they shall have the most effect to open or shut the door.

FIG. 2. Join *c c* the centres of the hinge, make the angles *c c A*, and *c c B*, each half a right angle; then complete the quadrants *A B*, and *A B*; then will *A B* be the distance that each crank ought to move, so as to make each door open to a right angle, and which will open with the greatest ease.

FIG. 3, shows the elevation of a crank to a larger scale, *D* is the side of a strap made on the crank, in *fig.* 4, shows the plan of the same. This strap is screwed to the under side of the door, in order to keep the crank firm.

E, in *fig.* 3, shows part of the edge of another strap made to the crank, which is screwed to the edge of the door upwards; this does not show in the plan *fig.* 4. These two straps will perfectly secure the cranks and keep them firm.

PLATE XLV.

A SASH FRAME.

The construction of a sash frame, and the manner of putting the several parts of it together.

FIG. 1, the elevation of the sash frame.

A B C D, the outer edge of it.

The dark perpendicular lines *E F*, *G H*, are grooves whose distances are from the edges of the sash frame *L M*, and *K I*, equal to the depth of the boxing, together with three-eights

Fig. 4.

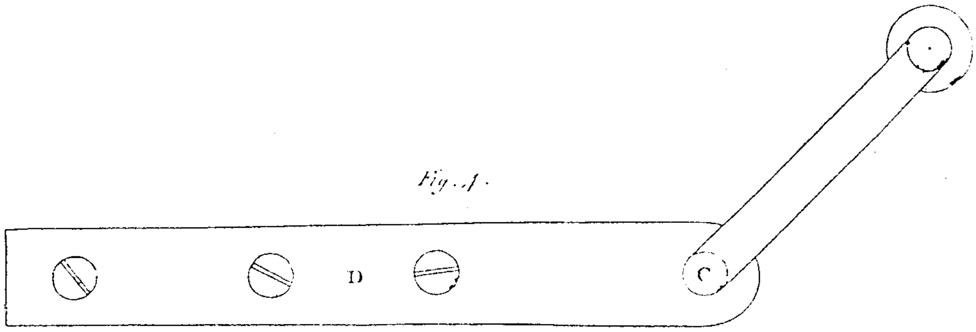


Fig. 3.

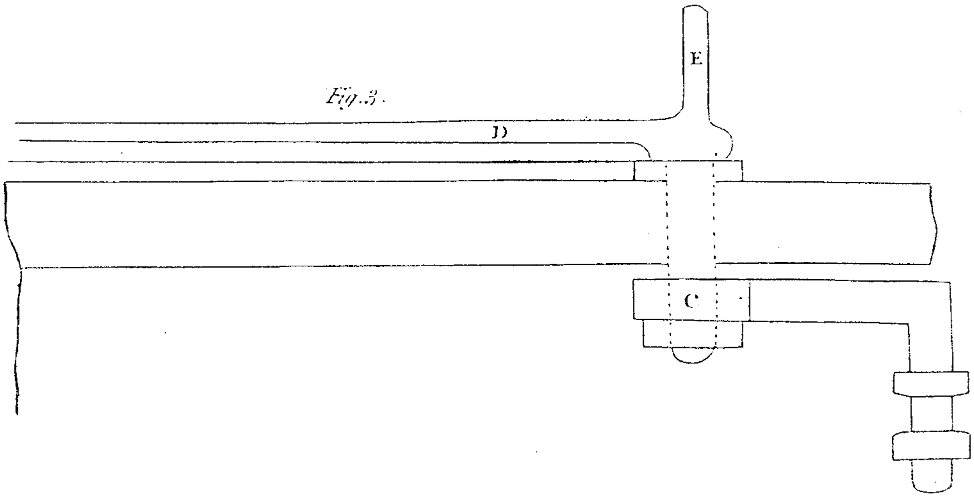


Fig. 1

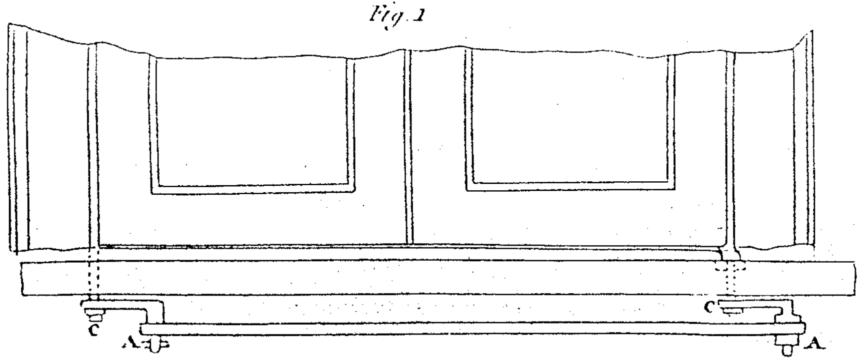
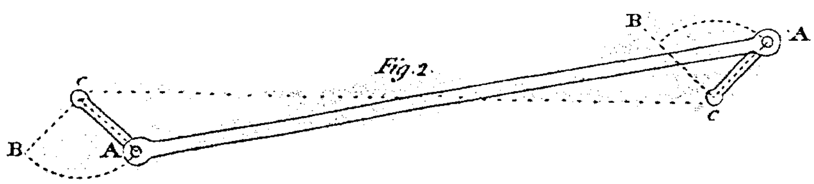


Fig. 2.



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Sash Frame.

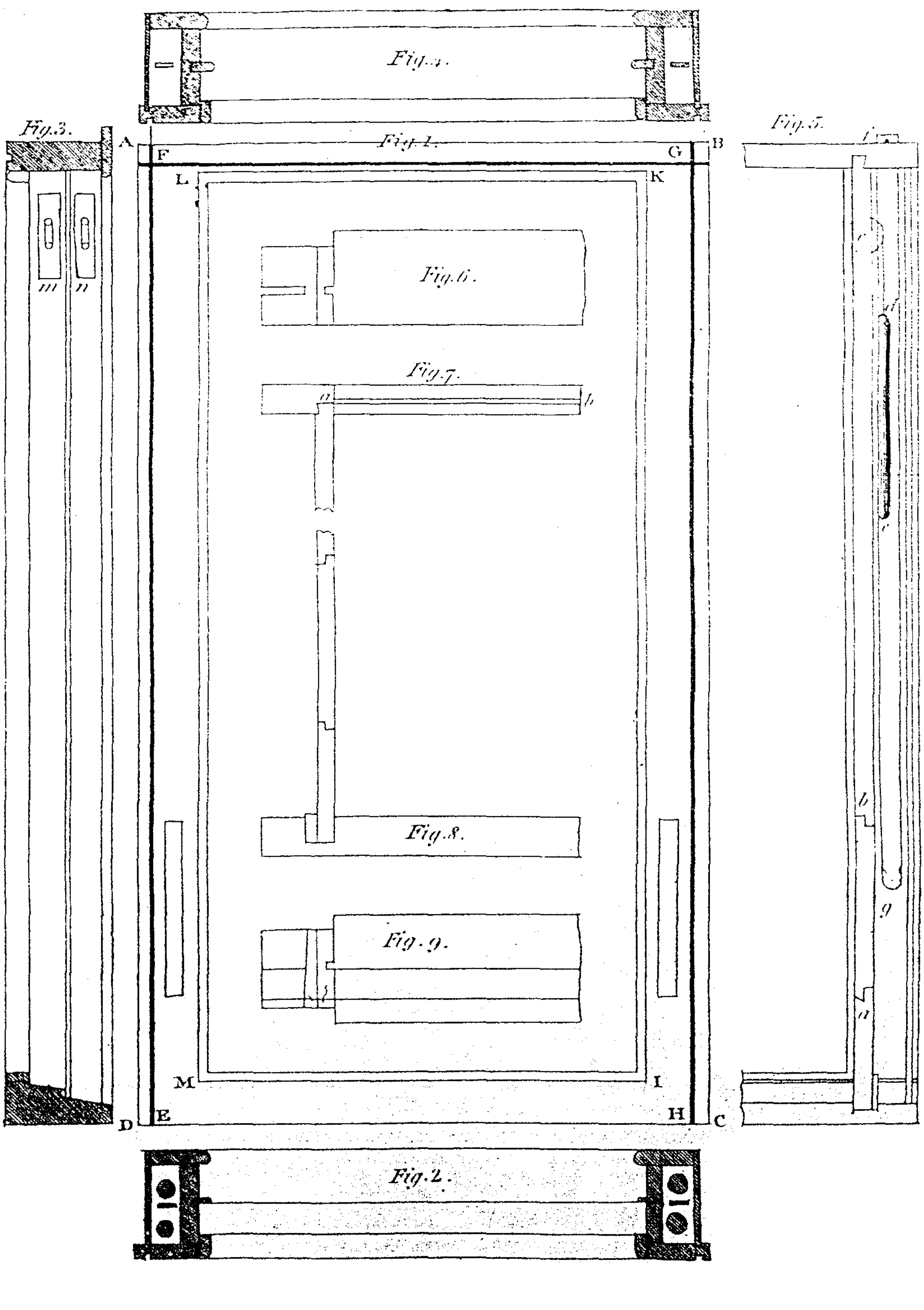

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Fig. 1.

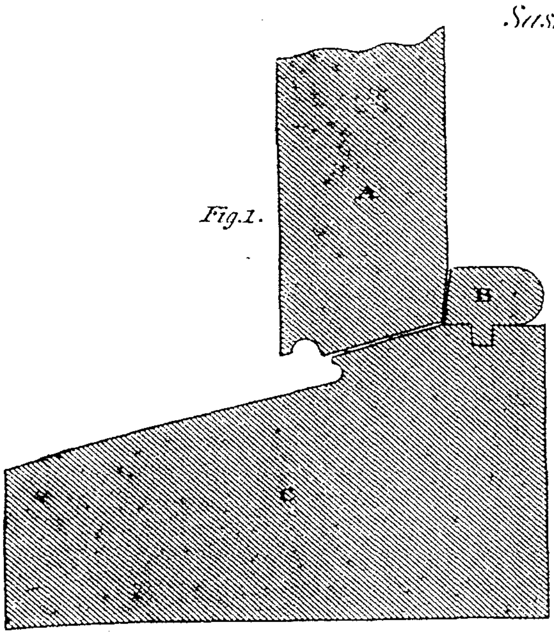


Fig. 2.

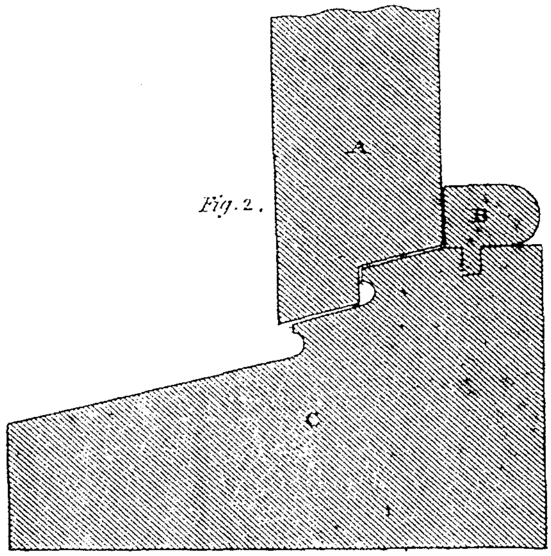


Fig. 3.

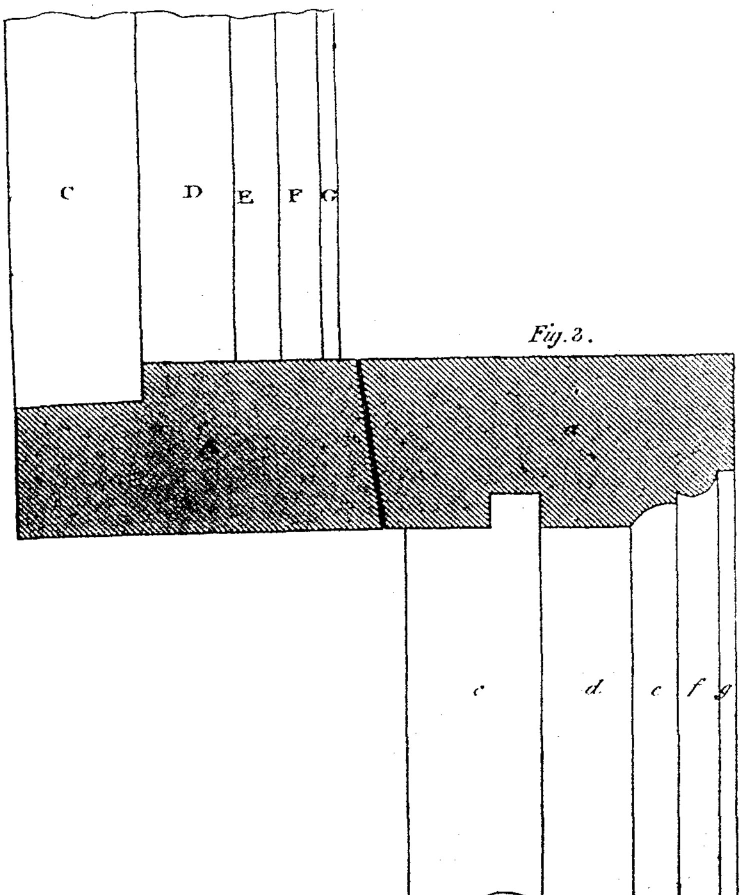
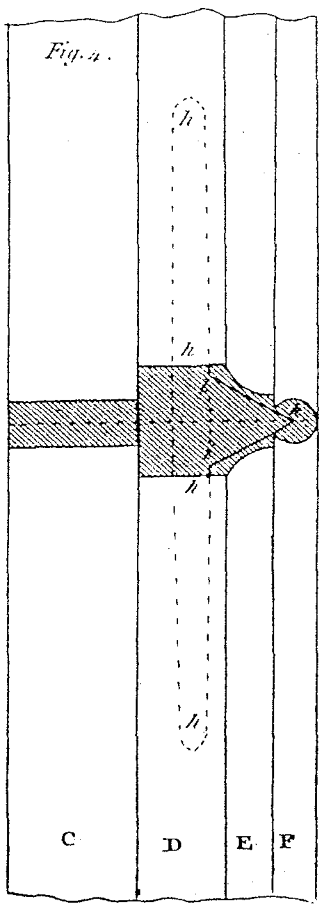


Fig. 4.



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three-eights of an inch more that is allowed for margin between the face of the ſhutter, when in the boxing, and the edges *M L*, and *K I*, of the ſaſh frame next to the bead.

FIG. 2, horizontal ſection of the ſides, ſhowing alſo the plan of the ſill.

FIG. 3, a vertical ſection of the ſill and top, ſhowing the elevation of the pulley ſtyle *m* and *n*; the pulleys let into the pulley piece.

FIG. 4, the horizontal ſection of the ſides, ſhowing alſo a plan of the head of the ſaſh frame.

FIG. 5, the elevation of the outer ſide of the ſaſh frame: the outſide lining being taken away in order to ſhow the work within the ſaſh frame.

f g, the parting ſtrip faſtened by a pin; *e d*, one of the weights connected to the ſaſh by means of a line going over the pulley *c*; the other end fixed to the edge of the ſaſh.

Note.—The weight *e d* is equal to half the weight of the ſaſh.

FIG. 6, the head of the ſaſh frame before put together.

FIG. 7, the edge of *fig.* 6.

FIG. 8, the edge of the bottom, ſhowing the manner of putting the ſtyles into it.

FIG. 9, the plan of *fig.* 8.

PLATE XLVI.

SASH SILLS AND SASHES.

FIG. 1 and 2, ſections of window ſills, with ſections of the under rail of the ſaſh, ſhowing the beſt modes of conſtructing them in order to prevent the weather from driving under the ſaſh rail.

A, ſection of the bottom rail of the ſaſh.

B, ſection of the bead tongued into the ſill.

C, ſection of the ſill.

FIG. 3, ſections of the meeting rails, with the ſide elevations of the upright bars.

C, rabbet for the glaſs.

D, a ſquare.

E and *F*, an aſtragal moulding.

G, fillet.

Note.—The ſmall letters denote the ſame parts of the under ſaſh.

FIG. 4, ſection of an upright bar, with the plans of two horizontal bars, ſhowing the manner in which they are put together ſo as to keep the upright bars as ſtrong as poſſible.

The thickneſs of the tenon in general comes about one-ſixteenth of an inch to the edge of the hollow of the aſtragal, and cloſe to the rabbet on the other ſide.

b b a dowel to keep the horizontal bars ſtill firmer together.

Note.—The ſame parts in this have the letters of reference the ſame as *fig.* 3.

Note alſo, there is no rabbet made for the glaſs on the inſide metting rail; a groove is made to anſwer that purpoſe.

PLATE XLVII.

SHUTTERS.

Section of common ſhutters and ſaſh frame.

FIG. 1, *A*, ſection of the architrave of windows.

B, ground for the architrave.

F, back lining of the boxing, tongued into the ground *B*, and into the inſide lining *G*, of the ſaſh frame.

G, the inſide lining of the ſaſh frame.

H, the inſide bead.

I, the pulley piece.

K, the parting bead,

L, outſide lining.

M, back lining.

C C C, the front ſhutter hung to the inſide lining of the ſaſh frame *G* by means of the hinge *a*.

D D D, back flap or ſhutter hung to the front ſhutter by means of the hinge *b*.

E E E, another back flap hung to *D D D*, by means of the hinge *c*.

As in a window the whole of the light ſhould be ſhut out, the principle of ſetting out the ſhutters is, that each boxing ſhould contain as many ſhutters as will cover one half, that is from the centre of the hinge to the centre of the window.

o P Q R, plan of the lower ſaſh.

o the rabbet for the glaſs.

P, a ſquare.

Q, an aſtragal moulding.

R, a ſmall ſquare or fillet.

FIG. 2, the method of hingeing two back flaps together, ſhowing the manner of placing the hinge, when room is ſcanty in the boxes.

PLATE

Fig. 1.

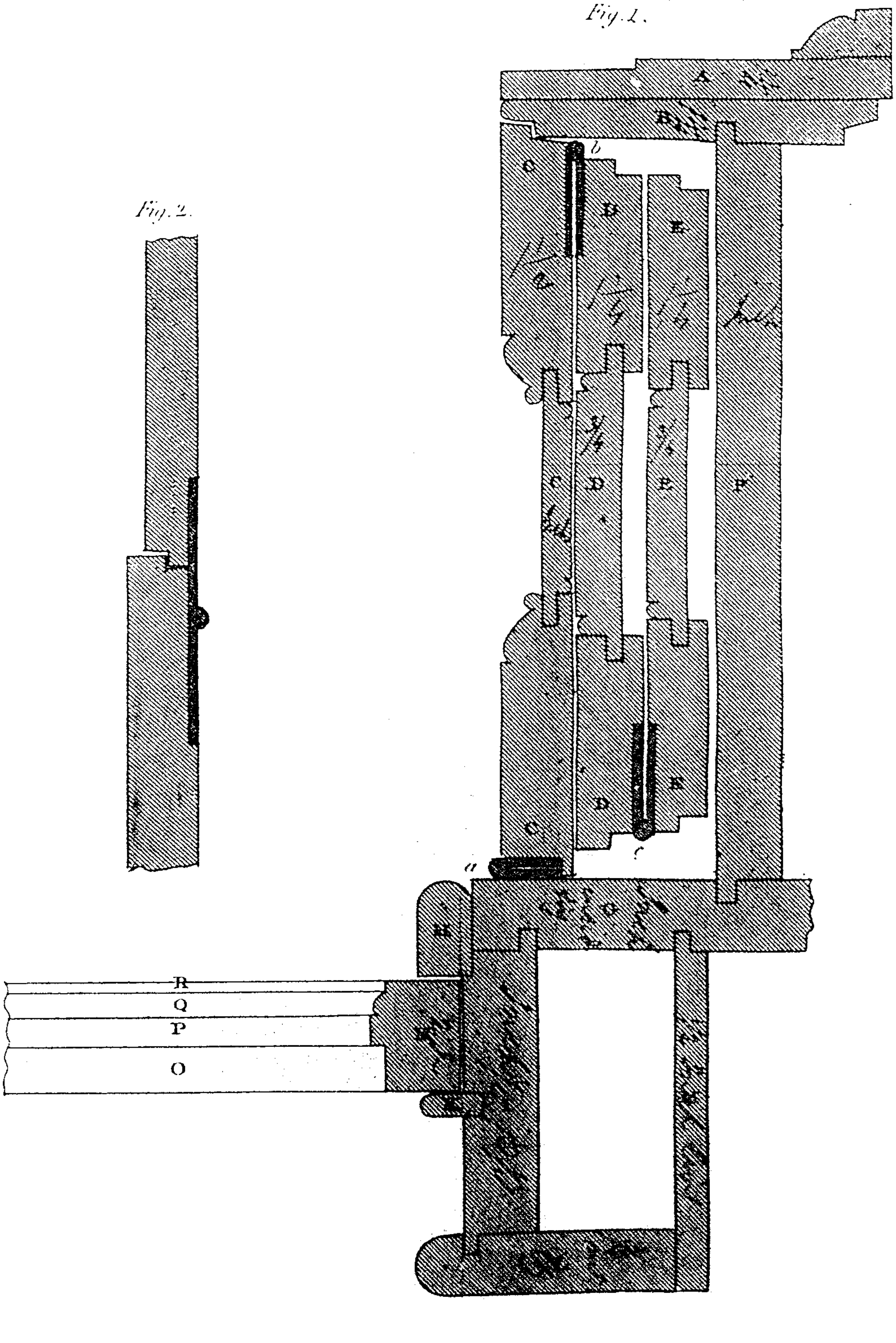

Fig. 2.

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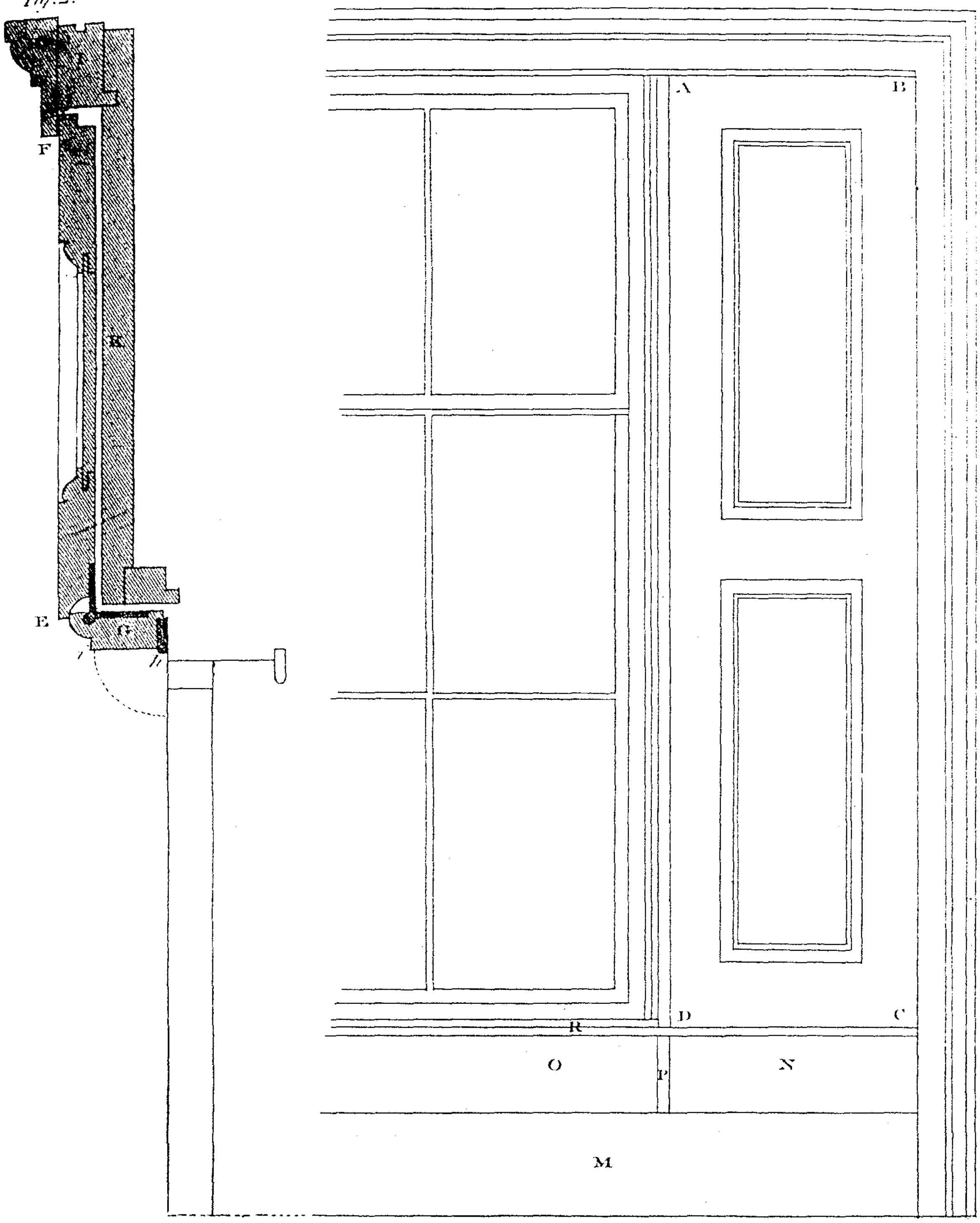
Fig. 2. *Fig. 1.*



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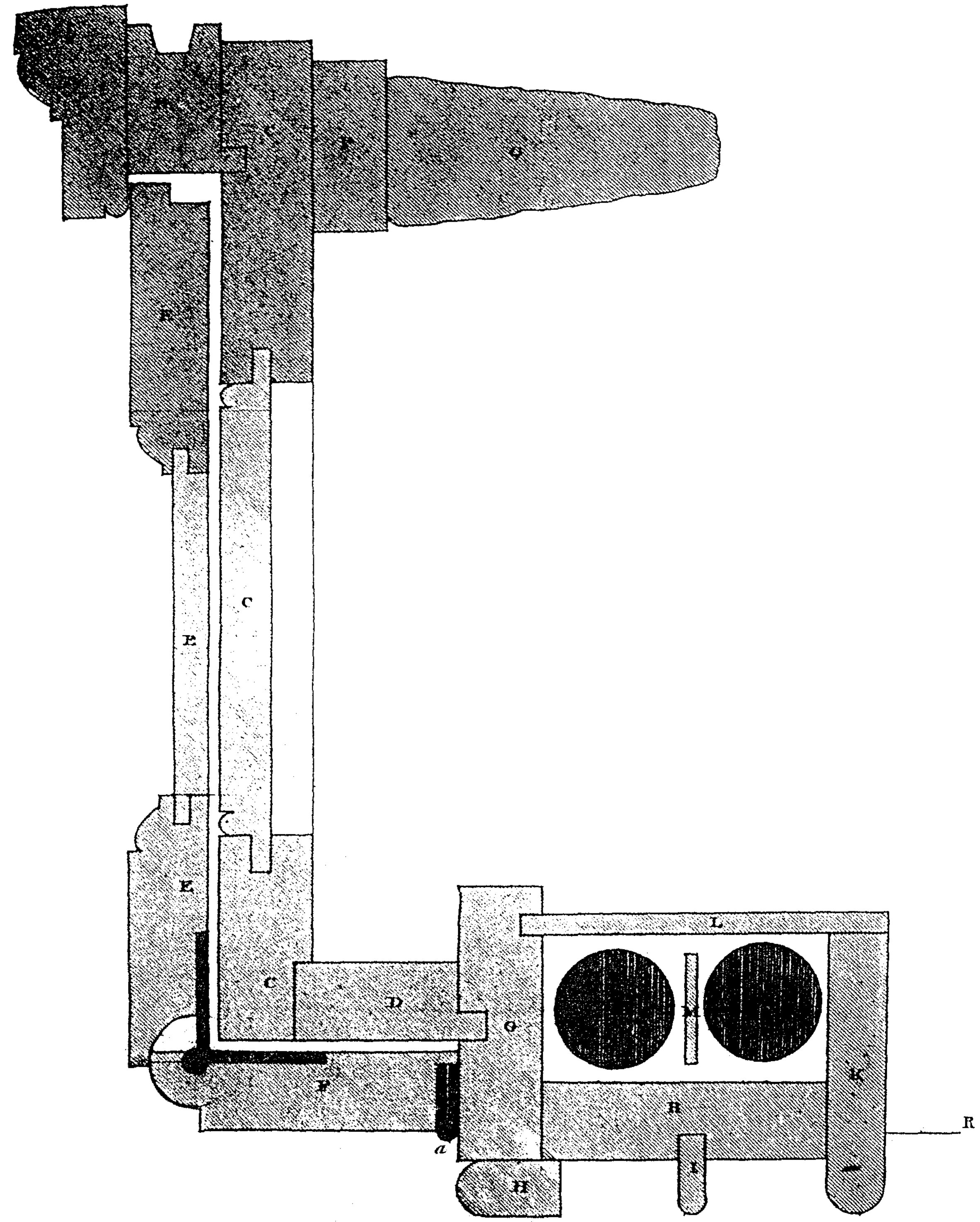

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PLATE XLVII.

SHUTTERS.

Elevation and plan of half a window adapted for a ſtaircaſe, when the wall of the building is not ſufficiently thick to admit of room for boxing.

FIG. 1, elevation of half the window.

FIG. 2, plan of the window to double the ſize of the elevation in order that the parts may be more diſtinctly ſeen.

E F, the breadth of the ſhutter, which is hung to a hanging ſtyle *G*, and the hanging ſtyle *G* is hung to the ſaſh frame by the hinge at *h*.

The whole breadth of the ſhutter *E L*, together with the breadth of the hanging ſtyle at *G*, that is *i h*, ought to cover exactly half the breadth of the window, or half the rabbet at *L*, more than half the breadth of the window.

H, architrave; *I*, back ground; *K*, back lining.

The pannelled part *A B C D*, at *fig.* 1, repreſents the ſhutter of which *E F*, in *fig.* 2, is the breadth.

The hanging ſtyle and ſhutter is hung together by means of a rule joint, as before deſcribed in plate 29.

Under the ſhutter *A B C D*, is a bead *R*, and continued acroſs the ſaſh frame to ſerve for a capping; *P* is a vertical bead continued in a line with the edge, at *D*, of the rule joint.

O and *N*, pieces of wainſcotting coming fluſh with the bead *P*, *M* the ſkirting board.

PLATE XLIX.

SHUTTERS.

A ſection of the preceding window, to a larger ſcale.

A, architrave moulding.

B, ground.

C C C, back lining.

D, the lining, or the return of the window.

E E E, the ſhutter hung to the hanging ſtyle *F*, which is hung to the ſaſh frame by the hinge at *a*.

G, the inſide lining of the ſaſh frame.
H, inſide bead.
I, parting bead.
K, outſide bead.
L, back lining.
M, the parting ſlip for the weights *N* and *O*.
N and *O*, weights.
P, ground fixed upon the plug.
Q, the plug.
R, pulley piece.

PLATE L.

SHUTTERS.

The plan, front, and ſide elevation, and ſection of a window proper for a building where the walls are not thick enough to admit of room for boxings, which will ſhow the ſame finiſh as if there were boxes for the ſhutters.

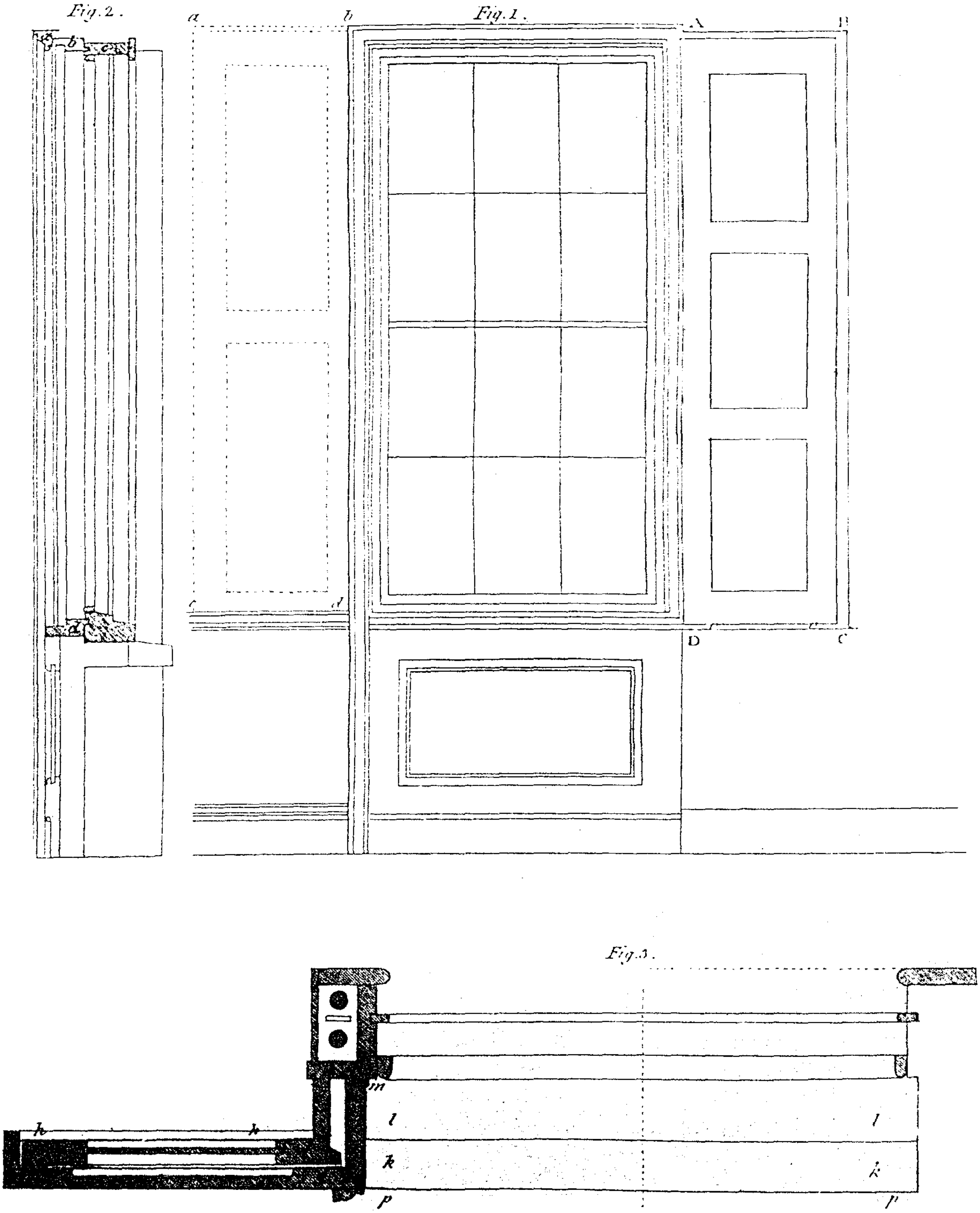
FIG. 1, front elevation of the window.
The dotted lines *a b c d*, repreſent a piece of framing.
The other ſide, *A B C D*, repreſents a ſliding ſhutter in the wall.
The framing is ſuppoſed to be removed in order to ſhow the ſhutter.
FIG. 2, the ſide elevation and ſection, ſuppoſing the ſhutter removed.
a, an architrave moulding.
b, ſoffit.
c, top of the ſaw frame.
d, capping tongued into the ſaſh frame ſill.
FIG. 3, horizontal ſection and plan of the window, twice the ſize of the elevation.
g g, ſection of the framing as ſhown by *a b c d*, *fig.* 1, by dotted lines.
h h, plaiſtering on the wall.
i i, a ſhutter hung to the ſaſh frame at *m*.
f f, ſection of the ſliding ſhutter, which runs on rollers.
k k, a flap which is let into a rabbet and hinged at the edge *p p*, ſo that when the flap is turned round, the hinges out of the rabbet, and the ſhutter *i i* turned to the face of the window, there will be a clear paſſage for the ſhutter *f f* to run out.

Not.—Although there is only a ſtop for the back of the ſhutter at the bottom, yet it is quite ſufficient as it is ſtopped on both ſides at the top, and as the edge of the ſhutter ſhould never be entirely out of the boxing.

This is more clearly ſhown by the parts drawn larger in the next plate.

PLATE

Shutters.



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Shutters.

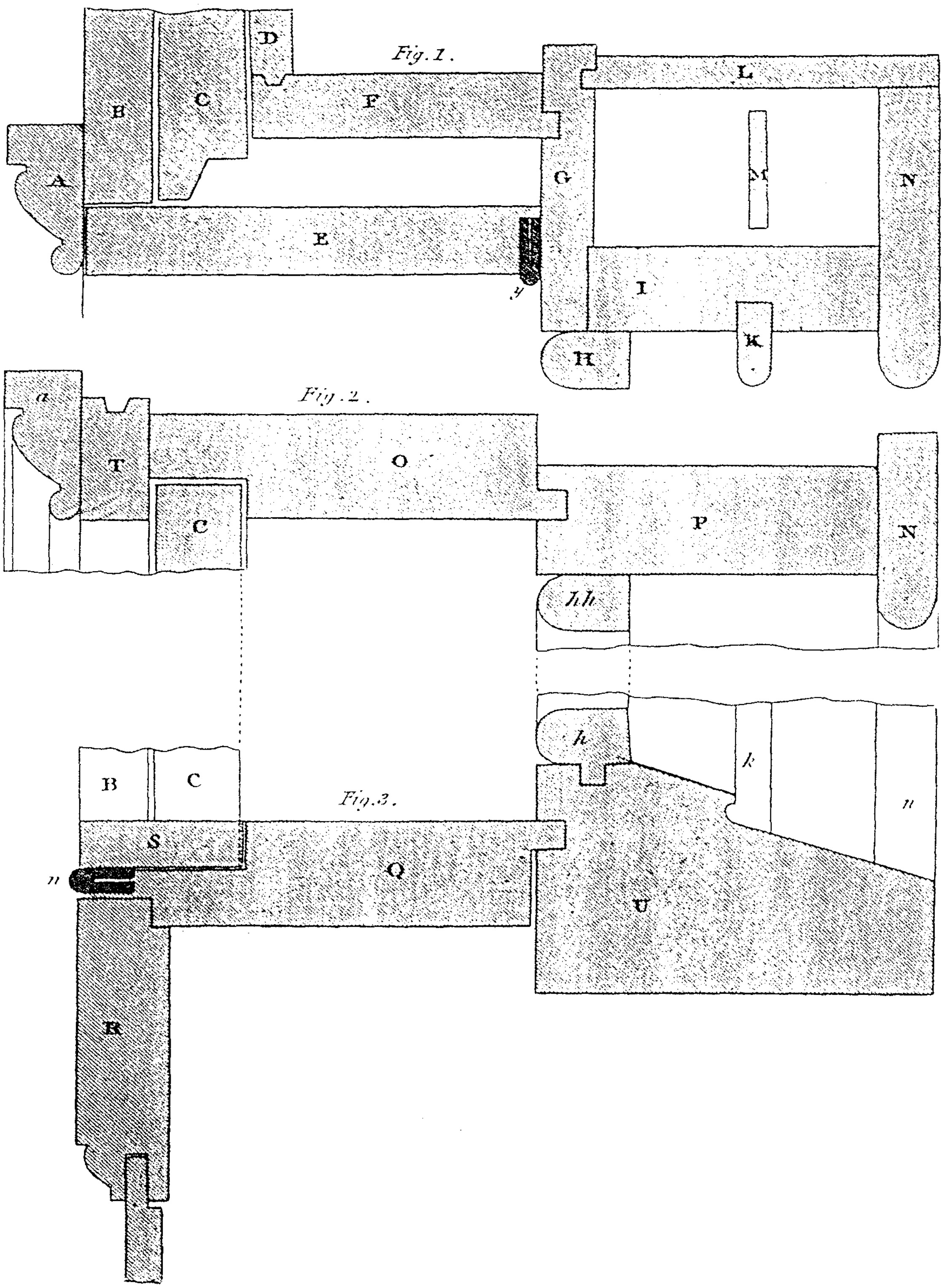

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PLATE LI.

SHUTTERS.

Different ſections of the foregoing plate.

FIG 1, horizontal ſection through the ſide of the window.

A, architrave moulding.

B, part of a piece of framing.

C, part of the ſhutter.

D, plaiſter or rendering upon the wall.

E, the front ſhutter hung to the ſaſh frame at *y*

F, back lining.

G, inſide lining of the ſaſh frame.

H, inſide bead of the ſaſh frame.

I, pulley piece.

K, parting bead.

L, back lining of the ſaſh frame.

M, parting ſtripe.

N, outſide lining.

FIG. 2, vertical ſection through the top of the window.

a, architrave moulding.

T, ground over the window.

C, ſection of part of the ſhutter.

O, ſoffit.

P, top of the ſaſh frame.

N, horizontal outſide bead.

b b, inſide horizontal bead.

FIG. 3, vertical ſection through the ſill of the window.

B, edge of the framing.

C, edge of the ſhutter.

Q, ſill rabbetted out at *S*, and tongued into the ſaſh frame ſill.

S, a flap hung to *Q*, by means of the hinge, at *n*; then by turning the front ſhutter upon the window, and by turning up the ſmall flap *S*, there will be a clear paſſage for the ſhutter *C* to run in.

PLATE

PLATE LII.

SHUTTERS.

Plan, elevation and section, of a window with shutters, which will show uniform and complete whether the shutters are open or shut.

FIG. 1, plan or horizontal section at *A B*, *fig.* 2.

FIG. 2, elevation or front of the window.

FIG. 3, vertical section at *C, D*, *fig.* 2, and side of the window.

E, thickness of the pilaster or architrave.

F, a bead stuck on its edge parting the edge of the pilaster from the shutter.

G, the breadth of the shutter.

H and *I*, a bead and square to correspond to the thickness of the architrave and bead, so as to show the same finish on each edge of the shutter; one edge of this finishes against the sash-frame above, and the same edge below finishes against the back of the window down to the plinth.

K, another square equal to the projection of the capping.

L, bead of the sash-frame.

M, thickness for the under sash to run in.

N, parting bead.

O, the thickness for the upper sash to run in.

P, outside lining and bead.

Q, the thickness of the outer brick work.

This is further explained on the next plate.

The principal sections are shown to a larger scale in the next plate.

a a, lintles made of strong yellow deal or oak.

b, the top of the ground.

c, the architrave fixed upon the ground *b*.

d d, the soffit tongued into the top of the sash-frame *e*, and on the other edge into the head architrave *C*.

f f, a hollow space between the soffit *d d*, and the lintles *a a*; the under edges of the lintles *a a*, are generally about four inches and a half above the camber of the outside of the window; but it may be less when there is any necessity for it, as for example, when you have very narrow grounds it may come down within a quarter of an inch of the soffit.

The face of the pulley style of every sash-frame ought to project beyond the edge of the brick-work about three-eighths of an inch; that is, the distance between the face of each pulley style ought to be less by three-quarters of an inch than the width of the window on the outside, so that the face of the shutters ought to be in the same plane with the brick work on the outside.

PLATE

Shutters.

Fig. 3.

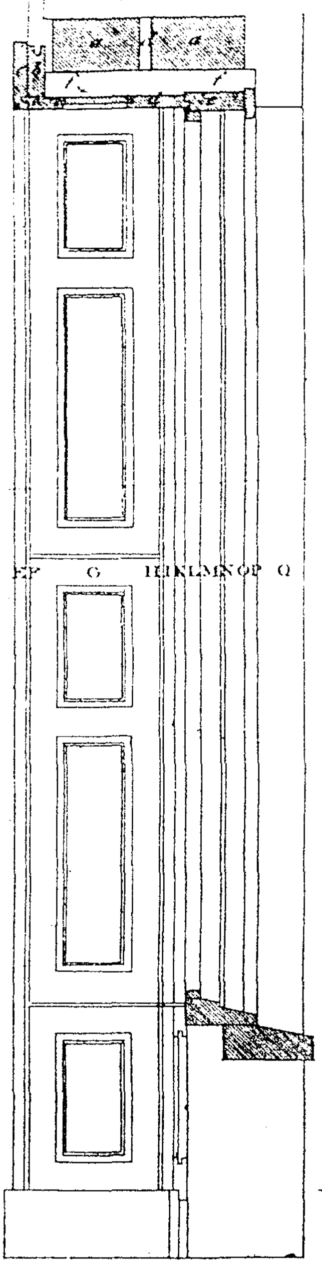
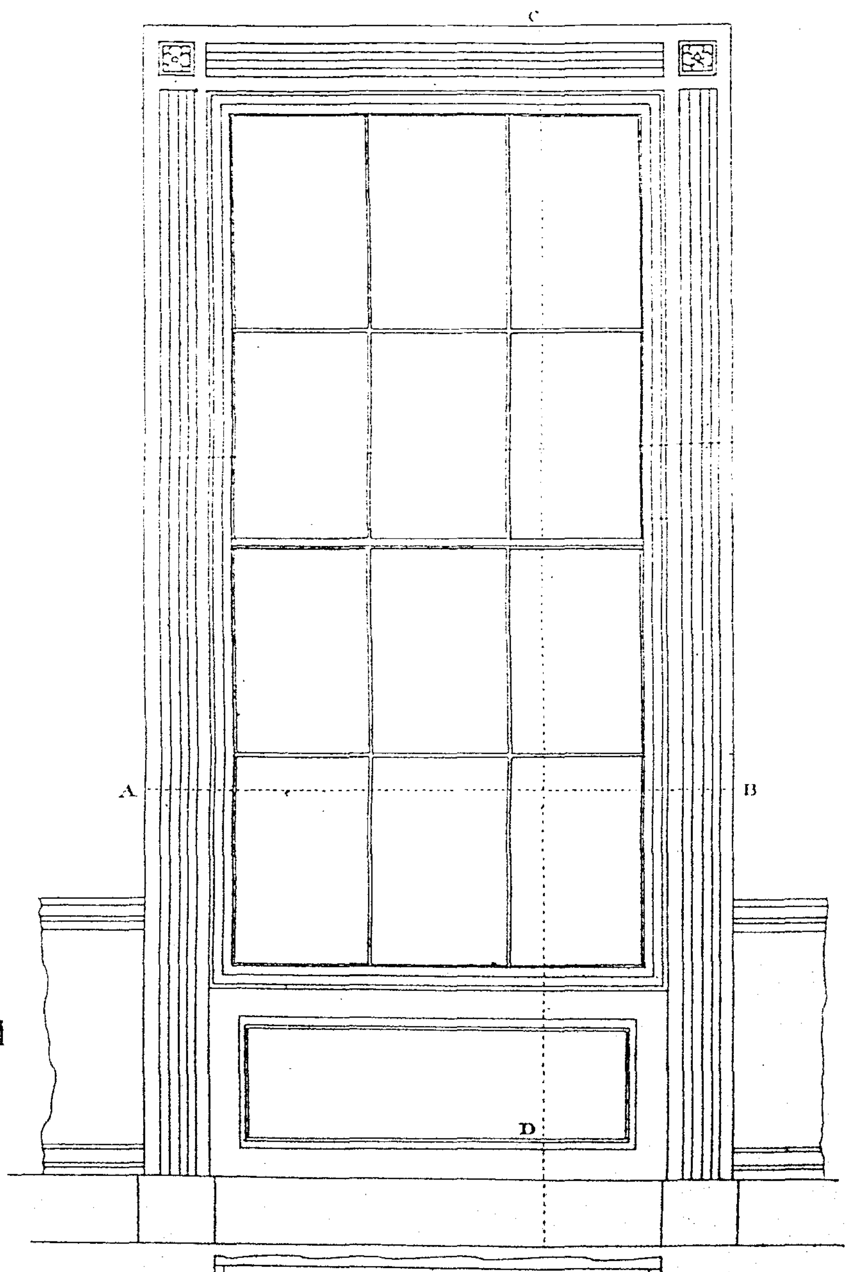


Fig. 2.



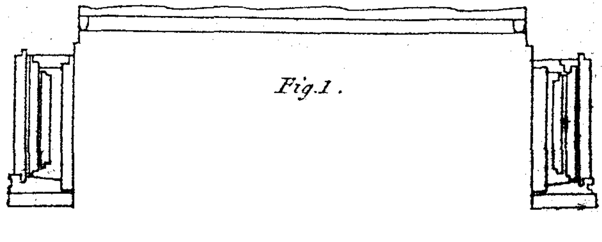


Fig. 1.

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Shutters.

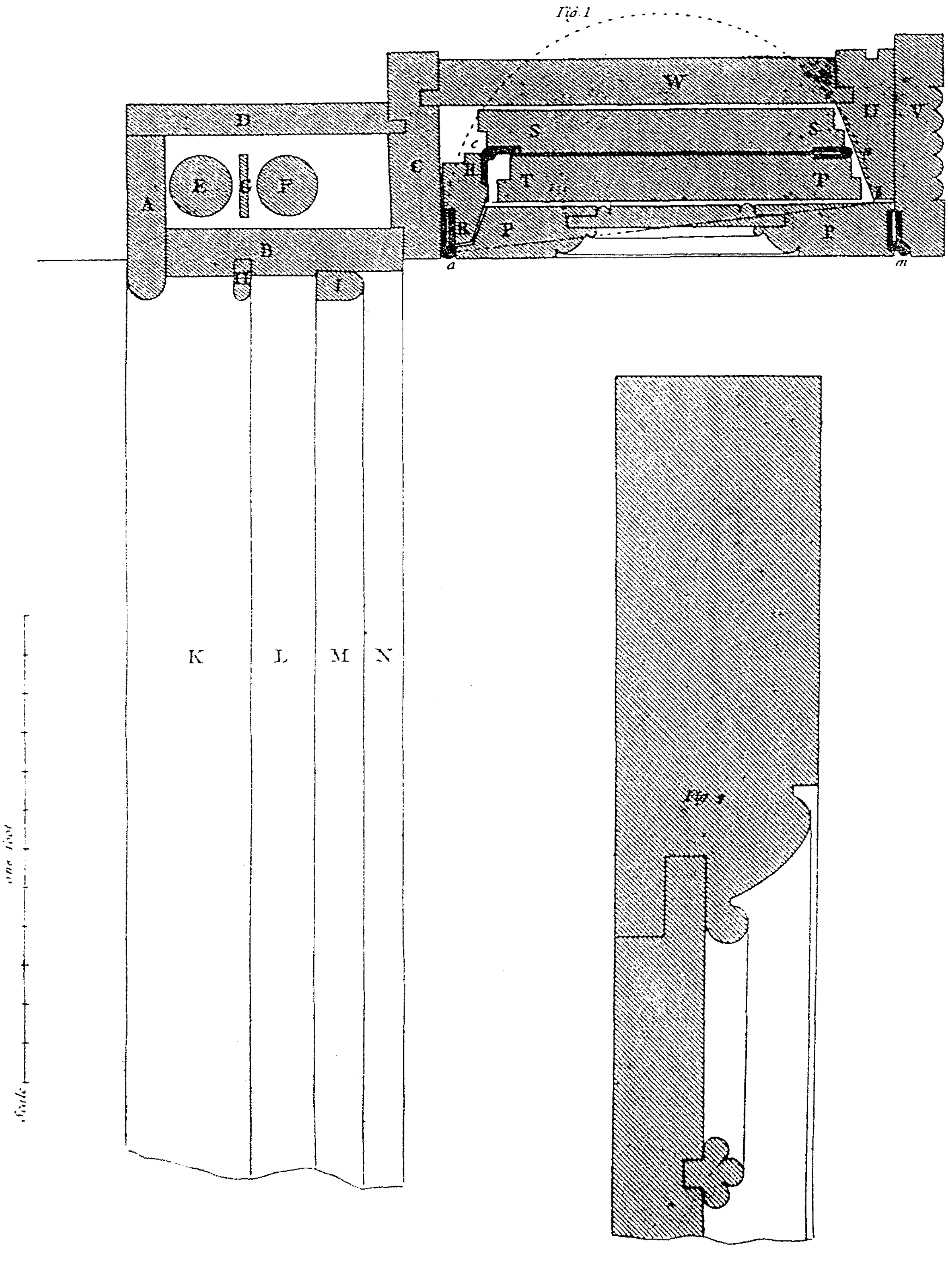

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PLATE LIII.

SHUTTERS.

Parts of the foregoing at large.

FIG. 1, plan of the ſhutters.
A, the outſide lining.
B, the pulley piece.
C, inſide lining.
D, back lining and outſide bead.
E and *F*, weights.
G, parting ſtrip.
H, parting bead.
I, inſide bead.
K and *L*, plan of the ſaſh-frame.
M, plan of the inſide bead.
N, plan of the capping.
R R, a hanging ſtyle hung to the ſaſh frame at
S S, a ſhutter hung to the hanging ſtyle at *e*.
T T, another ſhutter hung to *S S* at *n* if neceſſary.
P P, a door hung to the architrave at *m*, falls upon the hanging ſtyle *R R* by means of a rabbet.
Note.—The door muſt fall in a rabbet at top and bottom.
U, a ground to fix the architrave upon.
V, the architrave fixed upon the ground.
W, back lining.

When the window is to be ſhut in, the door *P P* is to be turned round the hinge *m*, parallel to the face of the ſaſh frame.

Then the ſhutters *R R*, *S S*, *T T*, being turned out on the hinge *a*, and on their ſeveral hinges, will cover that part of the window for which they were intended. The door *P* may then be cloſed, and the whole will have a uniform and neat appearance.

To find the ſplay of the ground b c.

Draw a line from the centre of the hinge at *a* to the edge of the ground at *b*; on *a b*, as a diameter, deſcribe a circle cutting the back lining of the boxing at *c*; join *c b* and it will be the bevil required.

PLATE

PLATE LIV.

SHUTTERS.

Front and two ſide elevations of a window, the ſaſh frame, being out of the ſquare, or an oblique angled parallelogram; ſhowing how to conſtruct the ſides of the window, ſo that the ſhutters ſhall make an equal margin round the edge of the ſaſh frame when the window is ſhut; and alſo to fit their boxings.

FIG. 1, elevation of the window; *A B C D* being the edge of the ſaſh frame next to the bead, and *E F G H* the margin for the window ſhutters.

The difficulty of fitting up a window of this kind may be ſurmounted if the following obſervations are attended to: the points *K* and *I*, *fig.* 3, being taken at the diſtance *E F*, *fig.* 1, and the point *R*, *fig.* 3, being made to correſpond to *K*, *fig.* 1, the middle of the metting rails, then

Make the angle *R H L*, *fig.* 3, equal to the angle *K E H*, *fig.* 1; through *R* and *I* draw *R S* and *I M* parallel to *K L*; then *K I M L* will be the front ſhutter, and *R S* the parting bead, in caſe the ſhutters are to be cut.

FIG. 2 is conſtructed in the ſame manner as *fig.* 3; that is, by making the angle *T O P* equal to the angle *E H L*, *fig.* 1; the points *O T N* being previouſly made to correſpond to *H L* and *G*, as on the other ſide.

FIG. 3, *A* and *B*, lintles.

C, the top of the ſaſh frame.

D, the ſoffit.

e, ground.

G, ſaſh frame ſill.

F, ſtone ſill.

PLATE LV.

SHUTTERS.

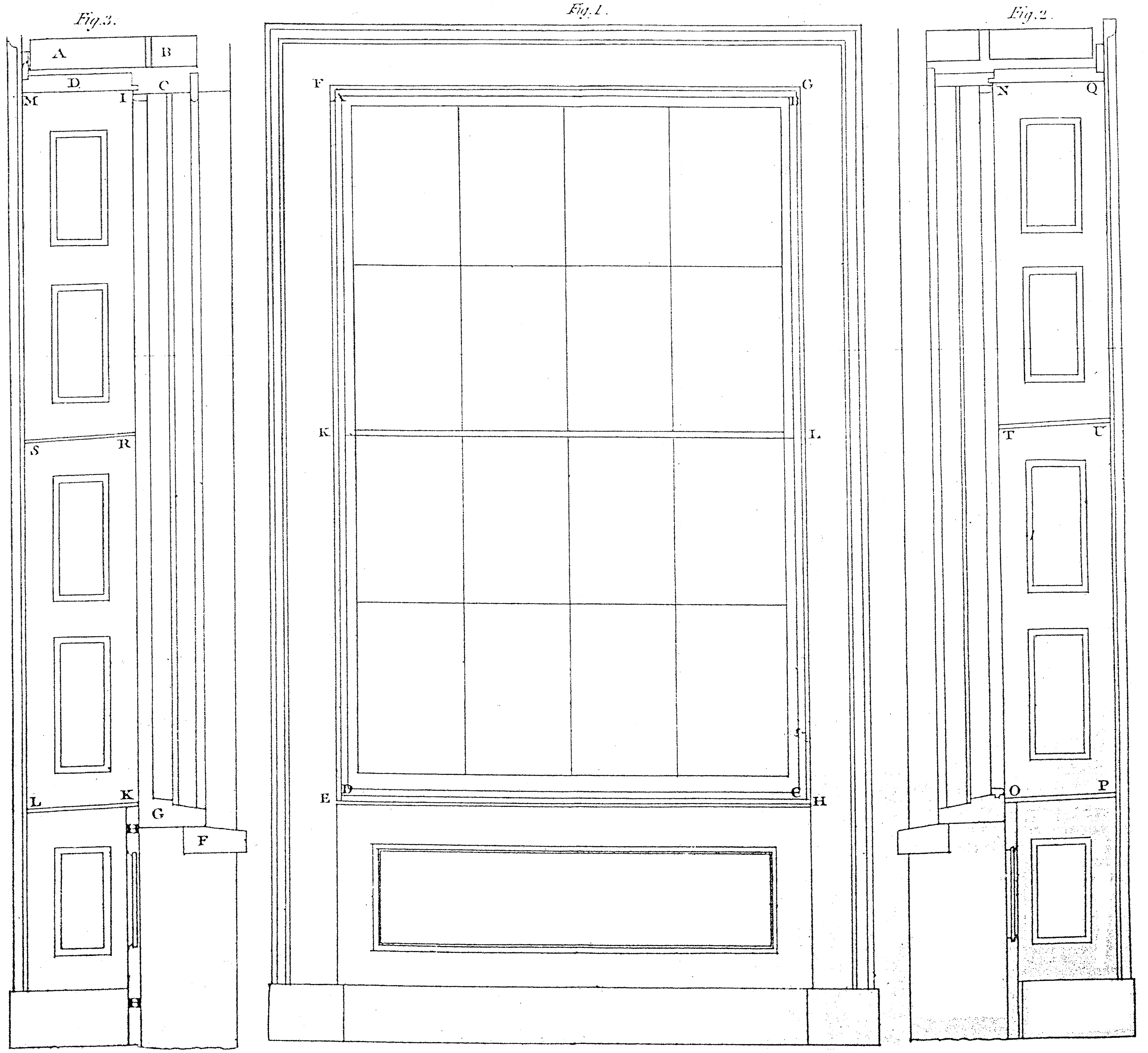
Plan and elevation of the ſhutters to the foregoing example; ſhowing the manner of hanging and cutting the ſhutters when the ſaſh frame is an oblique angled parallelogram, or out of the ſquare, as workmen call it.

Let *D C* and *A B*, *fig.* 2, be the top and bottom ends of the ſhutters parallel to each other; now, in order that the ſhutters may fit cloſe into their boxing, and alſo cloſe into the window-frame, the centres of the hinges to each flap muſt act in lines perpendicular to *D C* or *A B*.

How

Shutters.

Fig. 3. Fig. 1. Fig. 2.



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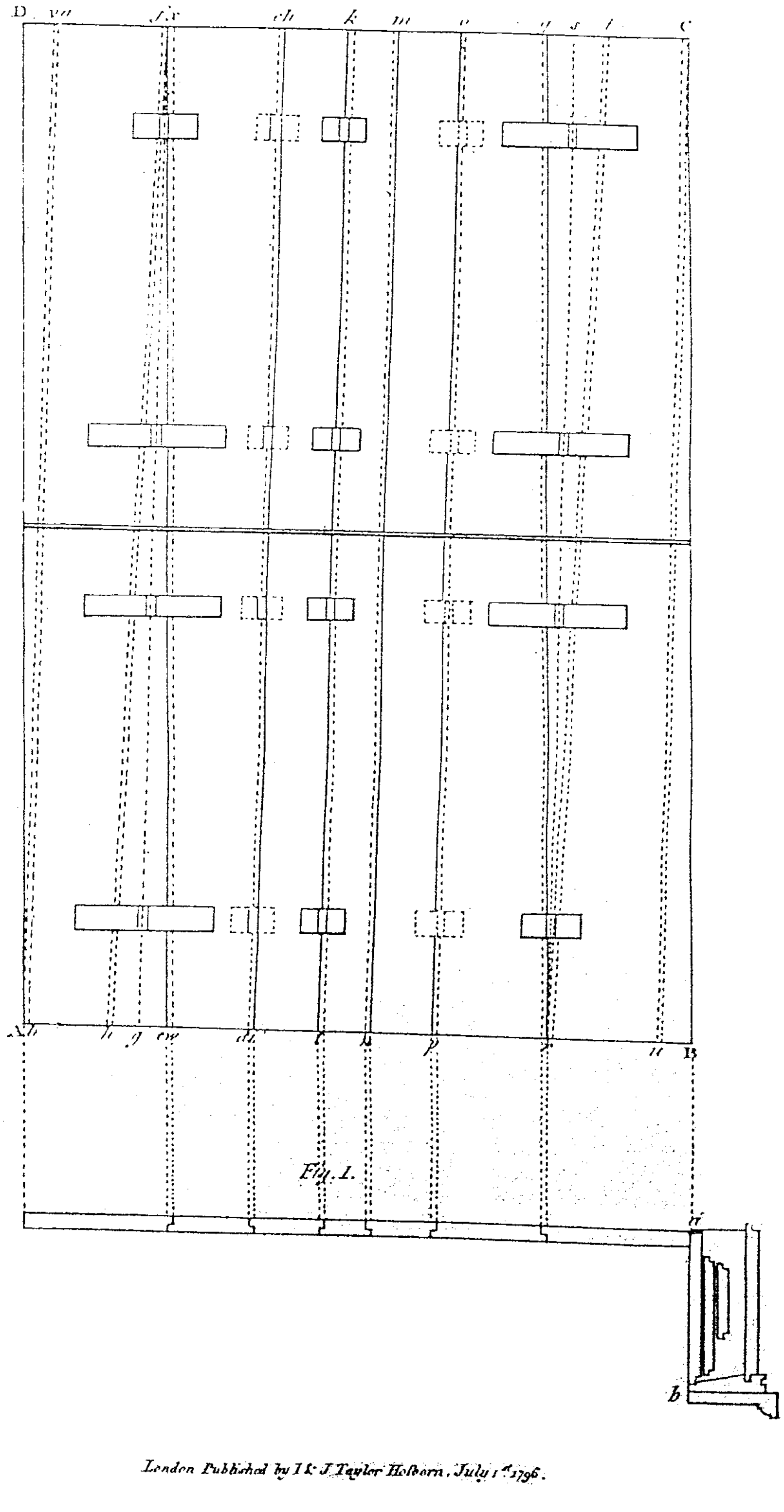
Shutters.

Fig. 2.



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How to ſet out the ſhutters.

Make $A\ e$ and $D\ f$, *fig.* 2, equal to the breadth of the front ſhutter $a\ b$, *fig.* 1, and draw the line $f\ e$; then will $A\ D\ f\ e$ repreſent the front ſhutter, and $f\ e$ the edge on which the next flap will join to it; then if the angle $D\ f\ e$ be not a right angle but obtuſe, from f draw $f\ g$ perpendicular to $D\ C$; then will $f\ g$ be the line on which the centres of the hinges muſt be placed. In the ſame manner $B\ C\ q\ r$ will repreſent the ſhutter on the other ſide; $B\ r\ q$ being the obtuſe angle, and $r\ ſ$ a perpendicular to $A\ B$ for the centres of the hinges for the joint $q\ r$: theſe two extreme joints being done, all the other joints $h\ i$, $k\ l$, $m\ n$, and $o\ p$, ought to be all perpendicular to the ends $D\ C$ and $A\ B$ of the ſhutters: then will the centres of the hinges be parallel to, or in the ſame line with, the joint.

How to find the breadth of the flaps which hang to the front ſhutters, ſo that they may be as wide as poſſible.

From the points A and C, the obtuſe angles, draw $A\ v$ and $C\ u$ perpendicular to the lines, or ends of the ſhutters, $A\ B$ and $D\ C$; make $v\ a$ and $A\ b$ equal to the breadth of the rabbet; and from the point f, and in the line of the centres of the hinges, make $f\ c$, $f\ h$, and $g\ d$, $g\ i$, reſpectively, equal to $f\ a$, $f\ v$, and $g\ b$, $g\ A$; then will $e\ f\ h\ i$ be the flap required; and it is plain from the nature of this window, that the other flap $o\ q\ r\ p$ muſt be the ſame figure as the flap $e\ f\ h\ i$, but inverted.

The other flaps may be filled in as the width of the window will admit.

Note.—I have given this example, not that I would in ſo diſtorted a caſe conſider it as worth the trouble it muſt neceſſarily coſt (it would be better certainly to rebuild it), but becauſe the method is a general one and will apply to all caſes, and becauſe I would adviſe the accurate workman never to truſt to the ſaſh-frame being abſolutely ſquare, for they ſeldom are; and if the variation be ever ſo ſmall, there will be a very conſiderable error in the ends of the ſhutters when incloſed in the boxings, if the rule contained in this example be not attended to.

PLATE LVI.

OF DIMINISHING AND ENLARGING MOULDINGS, &c.

From a given Entablature or Cornice, to draw another ſimilar to it, of any given height.

Let $A\ b$ be the height of the given entablature; from b, in $A\ b$, draw $b\ a$, making any angle with $A\ b$ from b; make $b\ a$ equal to the height of the intended cornice; join $A\ a$, then from all the heights on $A\ b$ draw lines parallel to $A\ a$, cutting $b\ a$, and from theſe points in $a\ b$ draw perpendiculars; then, in order to find the projections, bring all the projections of the given cornice to the line $D\ E$, and from the projections in the line $D\ E$ draw lines to B; make $B\ K$ equal to $b\ k$, and draw $K\ L$ perpendicular to $B\ K$, cutting all the projections drawn from $D\ E$ to the point B; from k draw $k\ f$ perpendicular to $b\ k$; from k make all the diſtances from k to f equal to the correſponding diſtances from K to L, which will give the projections of the cornice. In the ſame manner may the projections of the architrave be found, as is plainly ſhown by the correſponding letters $G\ H$ and $g\ h$.

PLATE LVII.

RAKING MOULDINGS.

How to deſcribe all kinds of raking mouldings for pediments, whether ſtraight or circular.

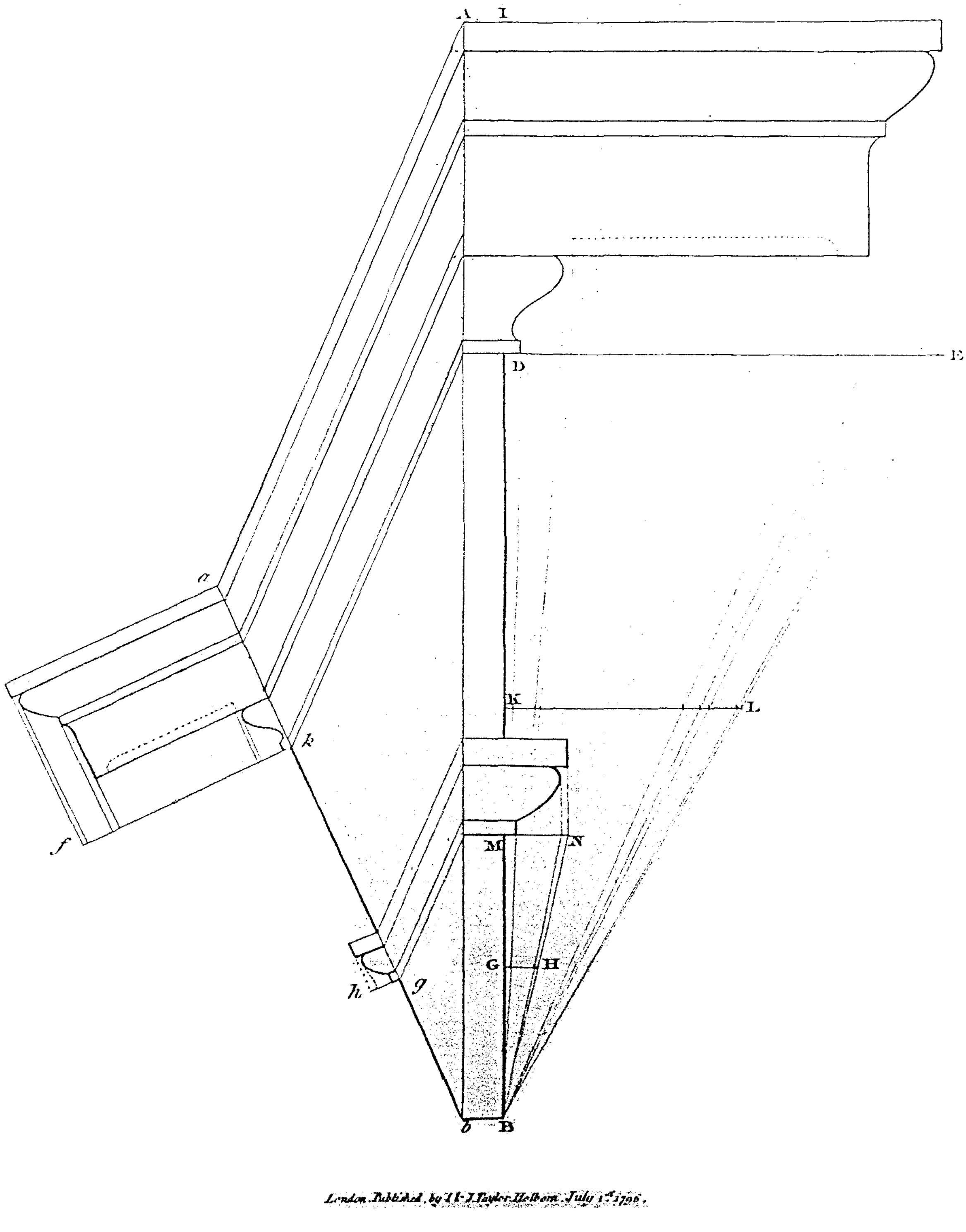
FIG. 1. Elevation of a circular pediment.
FIG. 2. Elevation of a triangular or ſtraight pediment.

How to deſcribe the raking mouldings of pediments, ſuch as fig. 1 *and* 2, *for working the face or front moulding.*

FIG. 3 and 6. Let $B\ c\ b\ a\ A$, at No. 1, be the given moulding; in it take any points $a\ b\ c$ at pleaſure; from theſe points draw lines $c\ c\ c$, $b\ b\ b$, and $a\ a\ a$, parallel to the fillets $B\ B\ B$ or $A\ A\ A$ of the pediment; from the points $A\ a\ b\ c\ B$ draw the perpendiculars $A\ D$, $a\ d$, $b\ e$, and $c\ f$; draw any line $D\ E$ at right angles, to $A\ D$, $a\ d$, $b\ e$, $c\ f$ and $B\ E$, cutting them in the points D, d, e, f, E.

In *fig.* 3, draw any line $A\ D$ at right angles to the rake, cutting one edge of the upper fillet at D, No. 2; from D, No. 2, make the ſeveral projections $d\ e\ f\ E$ equal to $d\ e\ f\ E$

 at



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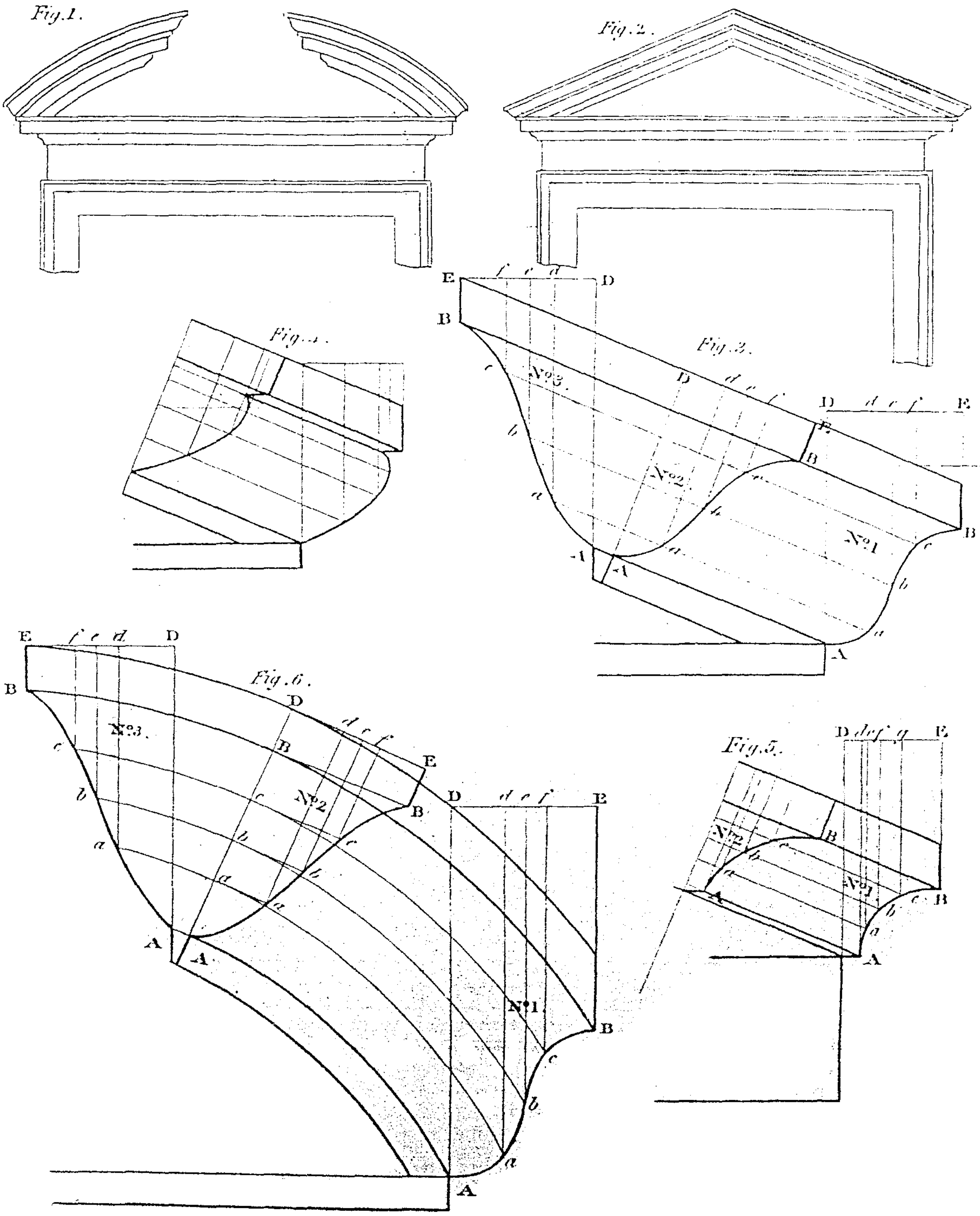
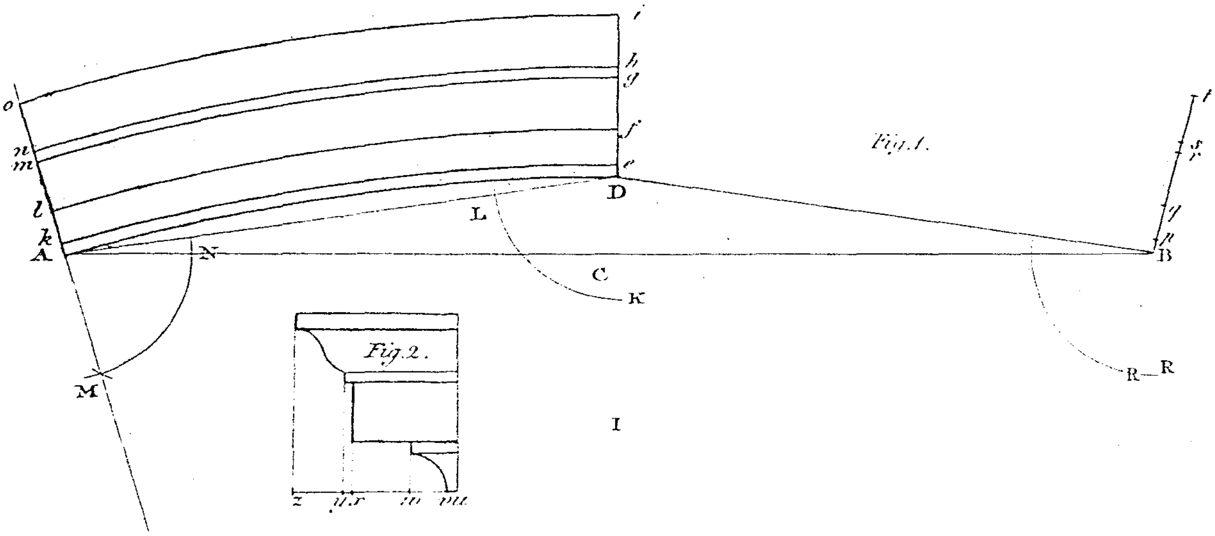
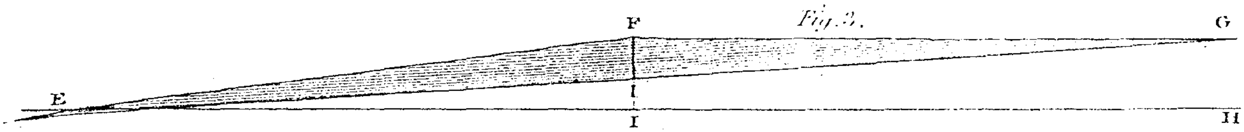
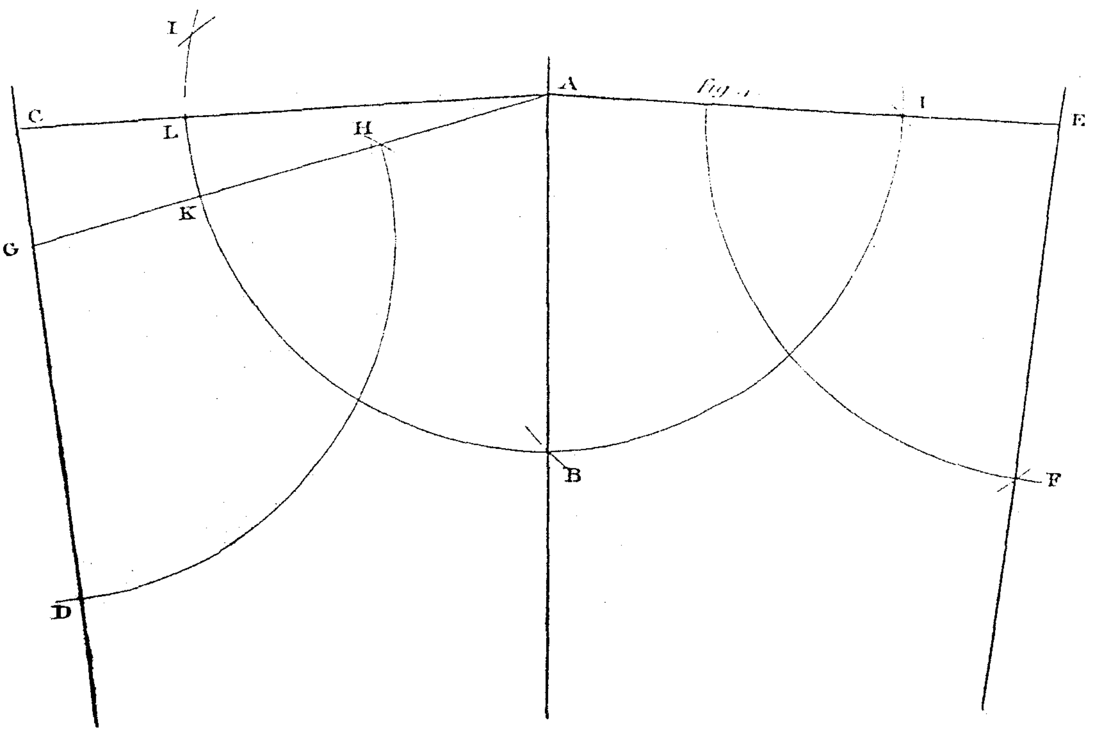


Fig.1.
Fig.2.
Fig.3.
Fig.4.
Fig.5.
Fig.6.
E f e d D
B
c
b
a
A
D d e f E
B
N°3.
N°2.
N°1.
c
b
a
A
D d e f g E
B
c B
A







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at No. 1; in No. 2 draw the perpendiculars *A D a d*, *b e*, *c f*, and *B E*, cutting *B B B*, *c c c*, *b b b*, *a a a*, at the points *a*, *b*, *c*, and it will give points in the curve through which it may be traced.

In *fig.* 6 draw any line *A D* to the centre of the pediment, cutting the lines *A A A*, *a a a*, *b b b*, *c c c*, *B B B*, and *D E* at *A*, *a*, *b*, *c*, *B*, *D*; from these points draw lines *D E*, *B B*, *c c*, *b b*, and *a a* tangents to their respective curves; then make all the projections *D d e f E* in No. 2, equal to those at No. 1, and from the points *D d e f E* at No 2, draw lines parallel to *A D*, cutting the tangents in the points *a b c B*, through which points the curve may be traced.

How to find the return moulding at the top in fig. 3 *and* 6.

Draw any line *D E* at No. 3, parallel to *D E*, No. 1, making all the projections from *D* to *d e f E*, at No. 3, equal to their corresponding distances *D d e f E* at No. 3; from the points *d e f E*, in No. 3, draw the perpendiculars *D A*, *d a*, *e b*, *f c* and *E B*, cutting *B B B*, *c c c*, *b b b*, *a a a*, and *A A A*, at the points *A a b c B*, will give points in the curve through which it may be traced.

Fig. 4 and 5, want no other explanation than what has already been described to *fig.* 3 and 6, as they differ only in form, and not in method.

PLATE LVIII.

OF SETTING OUT SHOP FRONTS ON A CIRCULAR PLAN.

How to draw a cornice or moulding of any kind, which is a very flat segment of a circle on the plan.

Let *A B*, *fig.* 1, be the length of the segment, and *C D* the projection; join *D A* and *D B*; make the angles *D A M* and *D B R* equal to the angle *A D C*; continue *M A* at pleasure to *o*; also produce *C D* to *i* and *R B* to *t*, make the distances *A*, *k*, *A l*, *A m*, *A n*, *A o*, and *D e*, *D f*, *D g*, *D h*, *D i*, likewise *B p*, *B q*, *B r*, *B s*, *B t*, equal to the projections of the cornice, *fig.* 2, at *u*, *v*, *w*, *x*, *y*, *z*; then make a triangular piece of thin board, *fig.* 3, *E F G*, in the following manner: that is, make *E I* equal to *A C*, and *I F* perpendicular to it equal to *C D*; join *E F*, and draw *F G* parallel to *E I*; make *F G* equal to *F E*, or more if you please; join *G E*; then will *E F G* be the form of a piece which will describe all the arcs *A D*, *k e*, *l f*, *m g*, *n h*, and *o i*, which will give one half of the cornice; the other half will be described in the same manner.

Given

Given two ſtraight lines inclining to each other, and a point in one of them, to find a point in the other, ſo that if both lines were produced till they meet each other, the point of interſection of the two lines may be the ſame diſtance from each point; alſo to find a third point, which ſhall be equally diſtant from the interſection, and alſo from the other points.

FIG. 4. Let *A B* and *C D* be the two lines given, and *A* the given point; through *A* draw any line *A G*, cutting *C D* in *G*; on *G*, as a centre, with any radius, deſcribe the arc *H D*, cutting *G A* and *G D* in *H* and *D*; on *A*, with the ſame radius, deſcribe the arc *B K L I*, cutting *A G* at *K*; make *B I* equal to *D H*; biſect *K I* at *L*, and draw *A L C*, cutting *D C*, produced at *C*, another point in the circumference; make the angles *E A B* equal to the angle *L A B*; make *A E* equal to *A C*, and the point *E* will be the third point required.

PLATE LIX.

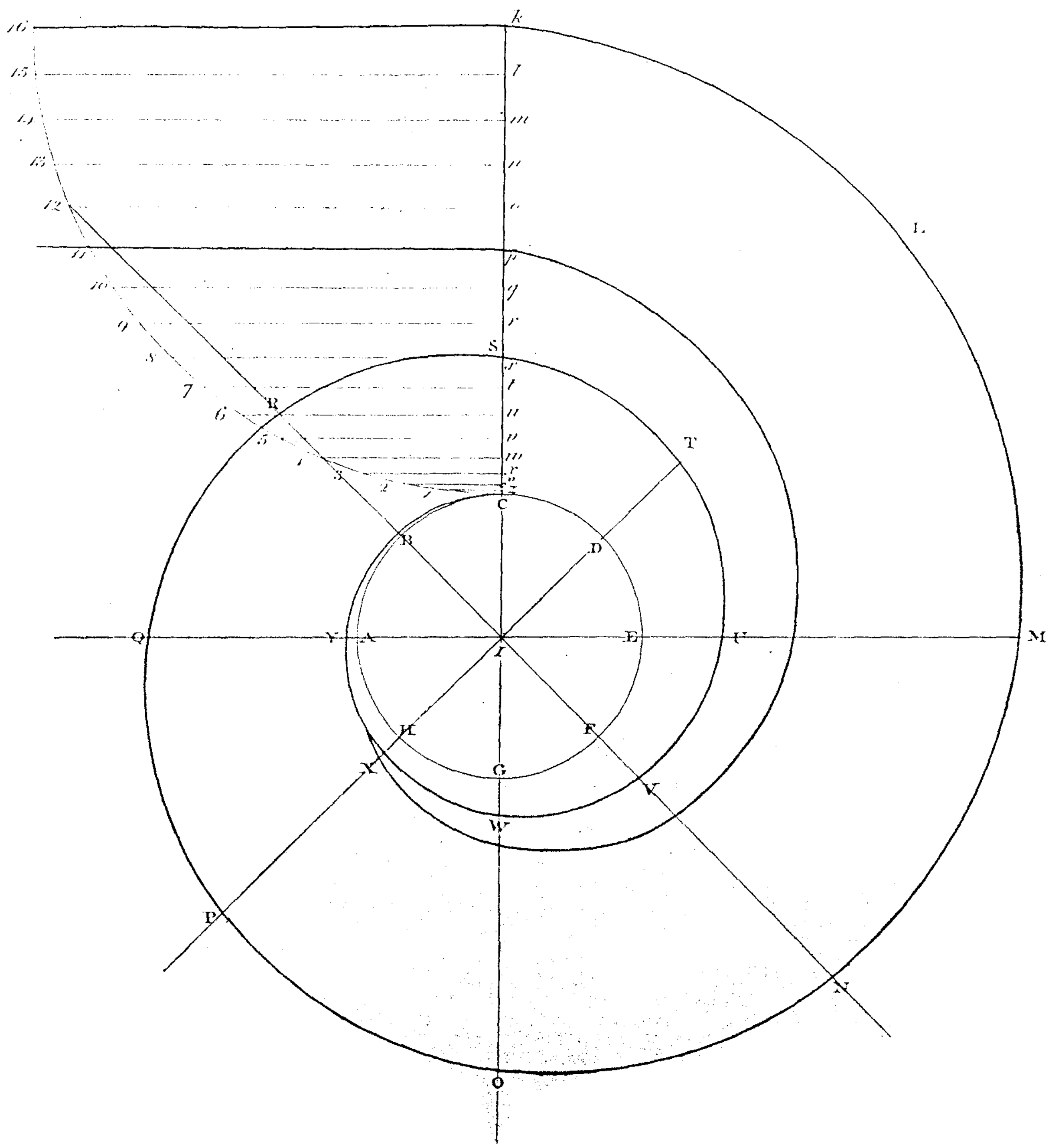
STAIR-CASES.

How to draw a ſcroll of a hand-rail to any number of revolutions that the width of the rail will admit.

Draw a circle *A B C D E F G H*, about three inches diameter, and divide the circumference into as many equal parts as you may think neceſſary; in this example it is in eight parts, at the points *A*, *B*, *C*, *D*, *E*, *F*, *G*, and *H*; through all theſe points, and from the centre *I*, draw lines *Q M*, *P L*, *O S*, *N R*: now ſuppoſe that *I k* is the diſtance you intend the centre of the ſcroll to be from the beginning of the twiſt; from *k* draw *k* 16 perpendicular to *C k*; on *k*, with the radius *k C*, deſcribe the quadrant *C* 1 2 3 4, 5, &c. cutting *k C* at *C*, and *k* 16 at 16: now ſuppoſe it were required to make two revolutions in this ſcroll, and ſince every revolution contains eight parts, there muſt be 16 in two revolutions; therefore divide the quadrant into 16 equal parts, and draw lines 15 *l*, 14 *m*, 13 *n*, 12 *o*, 11 *p*, &c. perpendicular to *k C*, cutting it at *l*, *m*, *n*, *o*, &c; from *I* make *I L*, *I M*, *I N*, &c. equal to their correſponding diſtances *I l*, *I m*, *I n*, *I o*, &c. and trace a curve round theſe points to the eye.

The outſide curve being now formed, the inſide one will be eaſily obtained by ſetting the thickneſs of the rail from the point *K*, *L*, *M*, *N*, &c. towards the centre *I*, and a curve being traced round theſe points will give the inſide of the rail.

PLATE



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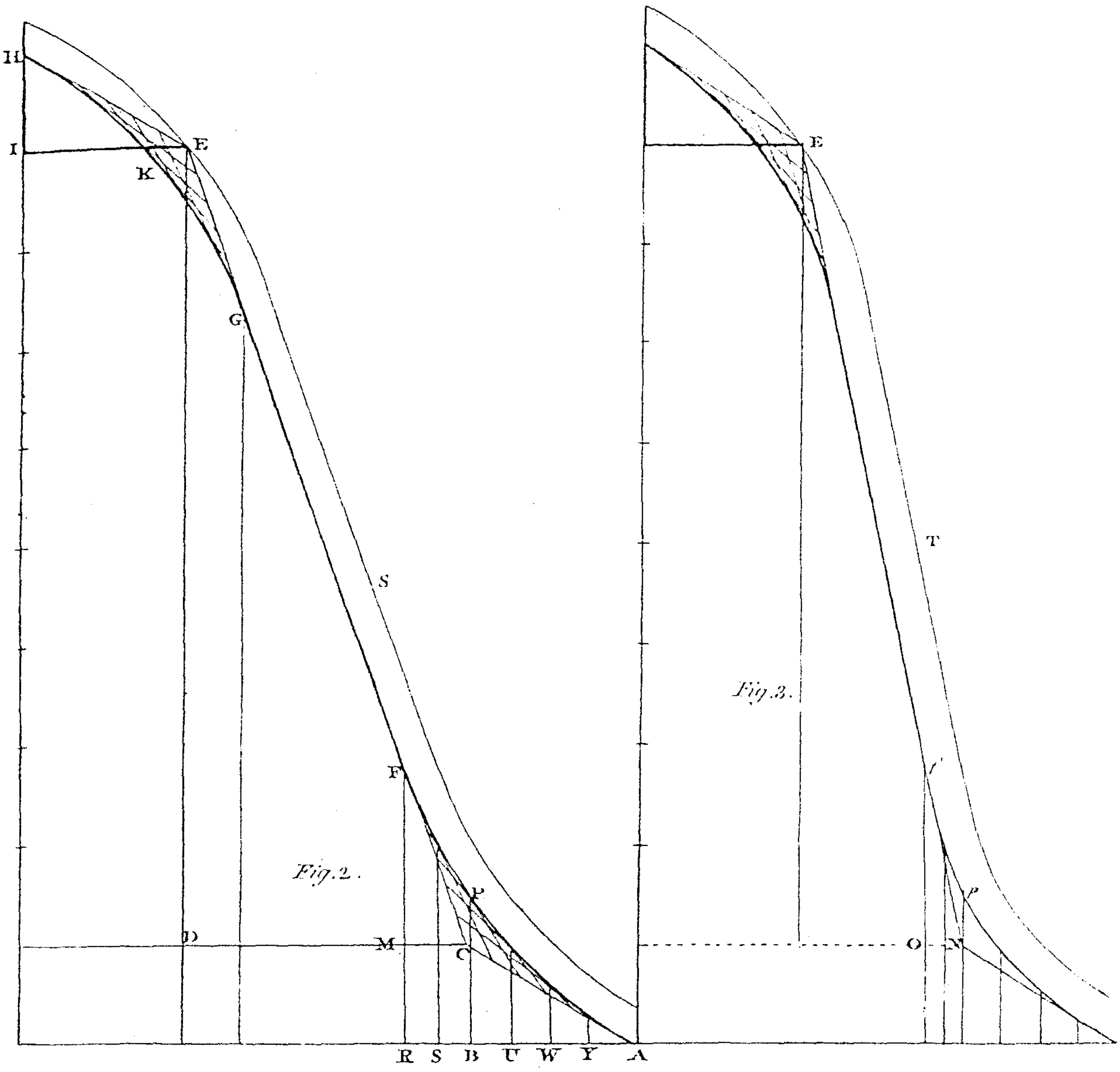

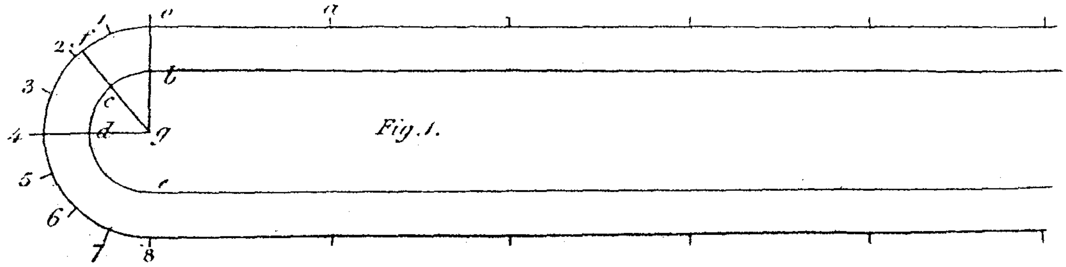

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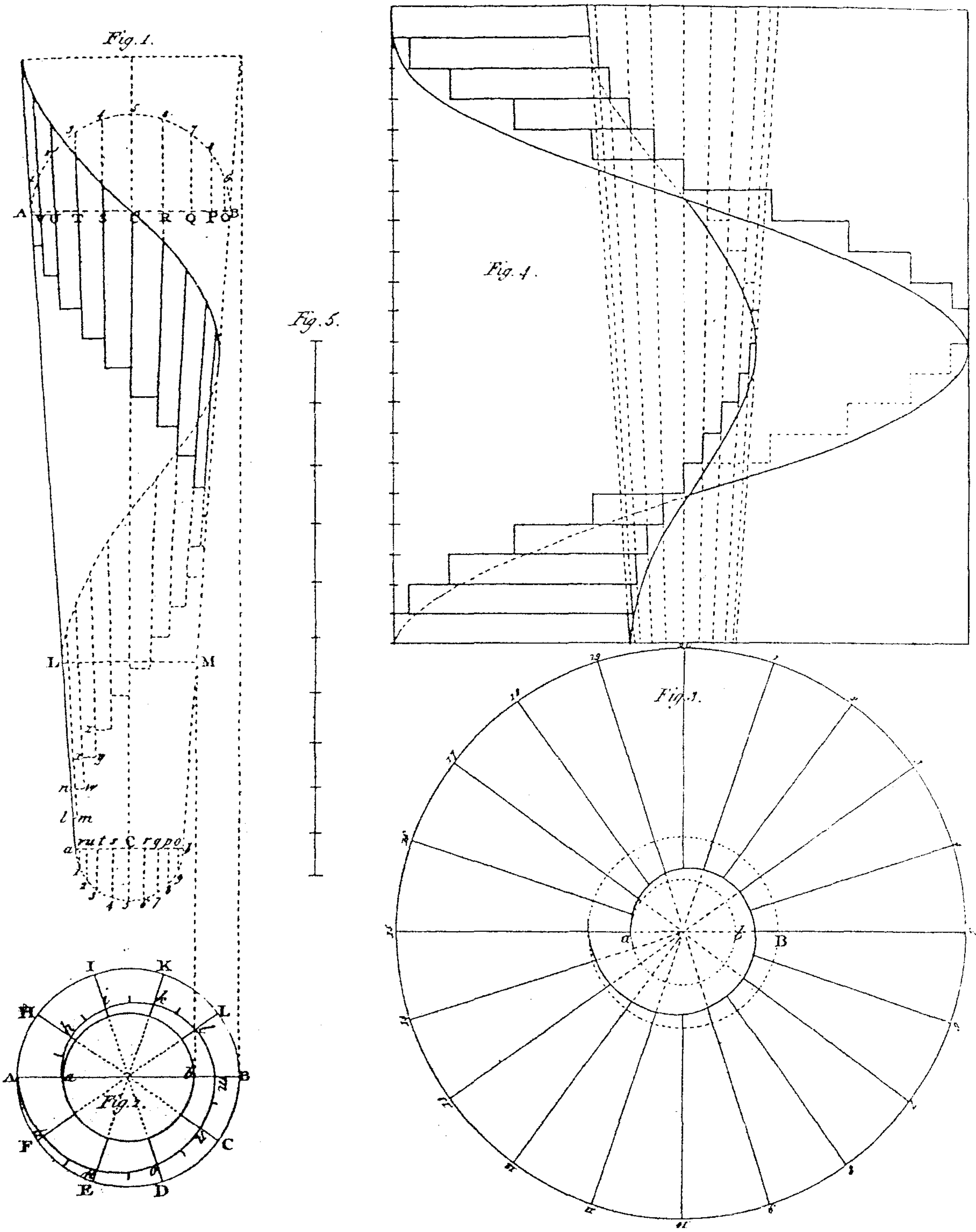

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PLATE LX.

STAIR-CASES.

How to find the form of the veneers for gluing a rail in thickneſſes.

Let *fig.* 1, be the plan of the rail, and the points 0, 1, 2, 3, 4, 5, 6, 7, 8, be the ends of the ſteps on the winders. Let *a o* be one of the ſlips on the flyers. Let *A B C* be the pitch-board, *fig.* 2, of the flyers; from *C* draw *C D* perpendicular to *C B*, and make *C D* equal to the circumference of the circular part round 0, 1, 2, 3, 4, 5, 6, 7, and 8; through *D* draw *D E* perpendicular to *D C*; then with your height-rod ſet up the heights of as many ſteps as you have winders, which in this example is eight; join *E C*; from *E* apply the pitch-board *E I H*, whoſe baſe *E I* is perpendicular to *E D*; from the points *E* and *C*, in the line *E C*, make *E G* and *C F* each equal to the hypothenuſe of the pitch-board, that is, *A C* or *E H*; then deſcribe the parabolas *H K G* and *F R A*, which will complete one edge of the falling mould; the other edge will be completed by drawing the line parallel to it; the other falling mould, *fig.* 2, will be completed in the ſame manner, only with this difference, by taking the circumference round the inſide at *b c d r*, inſtead of 0, 1, 2, 3, 4, 5, 6, 7, 8; take *M C*, *fig.* 2, and apply it from 0 to *f* in *fig.* 1; then draw *f g*, cutting the inſide of the rail at *c*; then take *b c* and apply it from *N* to *O*, by which means the curve from *P* to *Q* may be traced from *R* to *F*, and the whole curve *a z x v P t Q* may be traced from *A Z X V R T F*, as follows; divide the baſes *A B* and *a b* of the pitch boards, *fig.* 2 and 3, into the ſame number of equal parts; draw ordinates *Y Z*, *W X*, *U V*, *B R*, in *fig.* 2, and *y z*, *w x*, *u v*, *b p*, in *fig* 3; draw *F R*, parallel to *B P*, in *fig.* 1, and *r f*, parallel to *b p* in *fig.* 2; divide *R B fig.* 2, and *r b*, *fig.* 1, each into two equal parts, or any other number of like parts at *S* and *s*, draw *S T* and *s t* parallel to *B P*, and *b p*; then make all the ordinates *r f*, *s t*, *b p*, *u v*, *w x*, and *y z*, equal to the correſponding ordinates *R F*, *S T*, *B P*, *U V*, *W X*, and *Y Z*; then a curve being traced through the points *a*, *z*, *x*, *v*, *p*, *t*, *f*, will give the true curve of the under ſide of the falling mould in *fig.* 3, to correſpond exactly to the under edge *A Z X V P T F*, of *fig.* 2.

PLATE LXI.

To draw the elevation of a hand-rail and the ends of the ſteps for ſtairs, the well-hole being the fruſtum of a cone.

On each end of the fruſtum, at *A B* and *a b* as diameters, deſcribe a ſemicircle and divide the circumference of each into half the number of equal parts as there are intended

to

to be ſteps; from the points 1, 2, 3, 4, 5, &c. draw lines perpendicular to *A B* and *a b*, cutting them at *O*, *P*, *Q*, *R*, *S*, *T*, *U*, *V*, and *o*, *p*, *q*, *r*, *ſ*, *t*, *u*, *v*; divide the perpendicular height *C c* into one part more than the number of ſteps on the plan; that is, divide *C c* into 21 equal parts, which will give the height of as many ſteps; *a l* will be the firſt ſtep on the ſide *A a* of the cylinder; *m n* will be the end for the ſecond ſtep, by drawing a line from *V v*; *w x* will be the end for the third ſtep, by drawing a line from *u U*; and *y z* for the fourth, until you get to the other edge of the fruſtum *b B*, which will complete one half of the flight; from thence you muſt draw the ſteps in the ſame order towards the ſide *A a* for the other half.

To find the line of the hand-rail on the fruſtum.

From the top of each ſtep draw lines in the direction *v V*, *u U*, *t T*, &c.; on each of theſe lines ſet up the height of the baluſters from the top of each ſtep upwards; and through theſe points trace a curve and it will give the line of the rail.

To draw the plan of the rail.

Draw a line *A B*, at *fig.* 2, equal to *X Y*, the diameter of the fruſtum, *fig.* 1, at the top of the rail; divide it into two equal parts at *c*; on *c* as a centre deſcribe a circle *A H I K L B C D E F*, which will repreſent a ſection of the conical fruſtum through *X Y*. Alſo take half *L M*, *fig.* 1; on *c*, *fig.* 2, as a centre, deſcribe a circle cutting *A B* at *a* and *b*; divide *A a* into any number of equal parts, as 10; alſo divide the circumference of the outward circle, beginning at *A*, into as many equal parts at *A*, *H*, *I*, *K*, *L*, *B*, *C*, *D*, *E*, *F*, *A*, as the line or diſtance between the ſame diameters *A a* is divided into; then draw the radii *c H*, *c I*, *c K*, *c L*, &c.; make *c h* equal to the radius *c a* of the leſſer circle, and one of the parts of *A a*; *c i* equal to *c a* and two parts; *c k* equal to *c a* and three parts; proceed in this manner, augmenting each ſucceeding radius one part more than the preceding one; then a curve being traced through all the points, will give the plan of the rail.

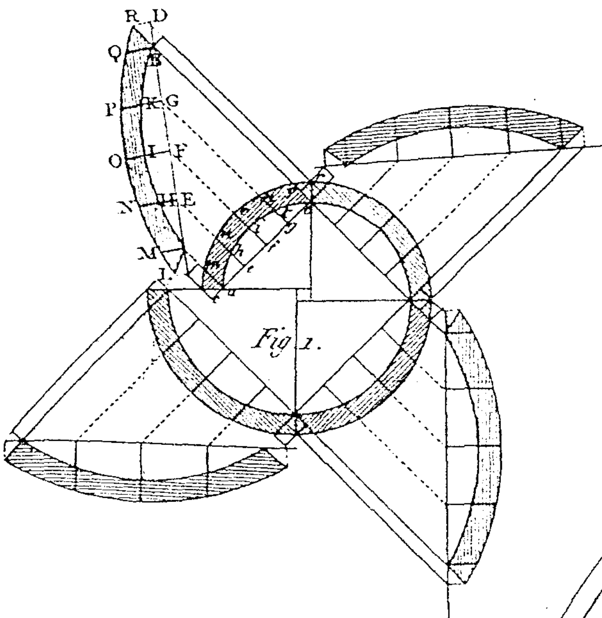
To draw the plan and elevation of the ſtair-caſe.

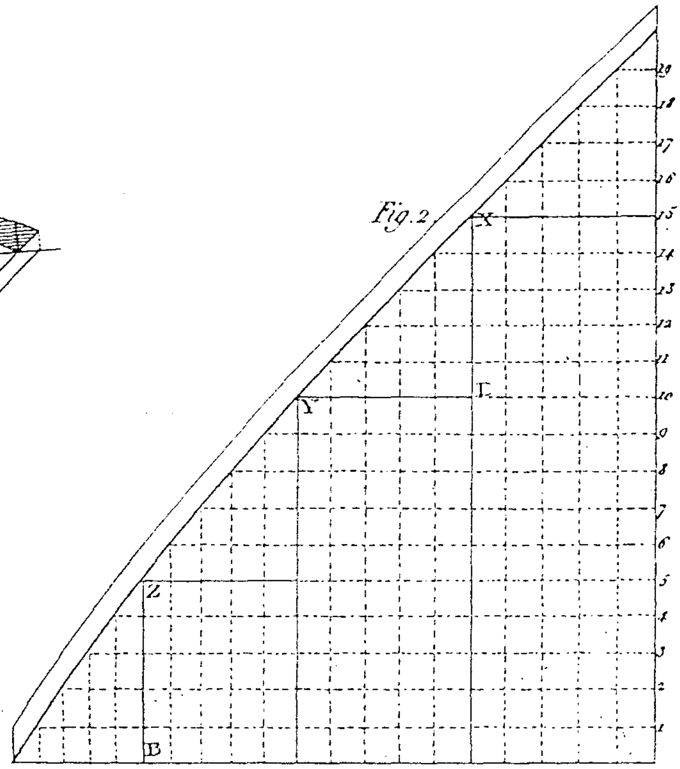
This elevation of the well-hole, *fig.* 4, is found in the ſame manner as in *fig.* 1. The plan at the ſteps, *fig.* 3, is found in the ſame manner as *fig.* 2, by taking *A B*, *fig.* 1, for the diameter *v B* of the outward circle at *fig.* 3, and *a b* the diameter of the lower end of the fruſtum, *fig.* 1, inſtead of *X Y* and *L M*; then the ſpiral line *a b c d e f g h i k l m n o p q r ſ t u v* will be the plan of a line touching the under angles of the ſteps.

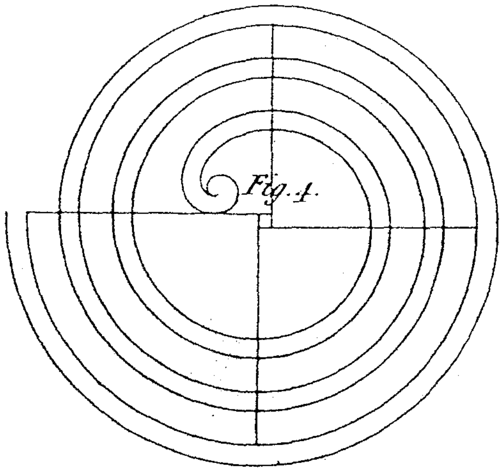
This ſtair-caſe is a complete circle, as in *fig.* 3, and the ſteps are equally divided round the circumference at 1, 2, 3, 4, &c. to 20; from theſe points draw lines tending to the centre, ending at the ſpiral line or plan of the rail; the elevation and ends of the ſteps in *fig.* 4, are found from the height-rod, and from its plan *fig.* 3.

FIG. 5, the ſtretch-out of the plan of the rail in *fig.* 2, which is explained on the next plate.

PLATE







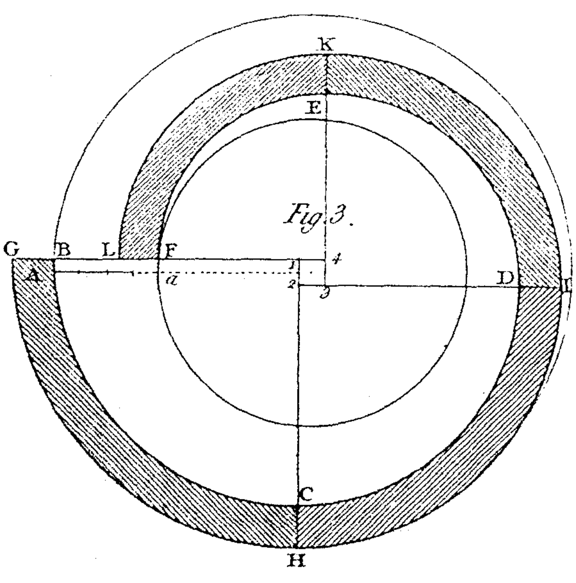


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PLATE LXII.

To find the falling mould for the preceding ſtair-caſe.

Take the ſtretch-out of *fig.* 5, in the laſt plate, and apply it to *A V*, *fig.* 2, and mark all the ſteps upon that line, which are twenty in number; make *V W* perpendicular to *A V*, on *V W* ſet up the height of twenty ſteps; the dotted lines being drawn from the treads and heights of the ſteps, and a curve being drawn, will give the under edge of the falling mould.

To find the face moulds for each quarter of the rail.

Lay down the plan and thickneſs of the rail as *fig.* 1, the manner of finding the curve line of it for the inſide of the rail has been ſhown in the laſt plate; then a line drawn equidiſtant round it, whoſe breadth is equal the thickneſs of the rail, will complete the plan, as is ſhown by the ſhaded part; divide the circumference round the inſide of the rail into parts reſpectively equal, *A B*, *Z C*, *Y D*, and *X* 15 in *fig.* 2; then to find a face mould for any of the parts, ſuppoſe *A B* on the falling mould, *fig.* 2, which correſponds to *a b*, on the plan *fig.* 1;

Draw the chord *a b*, and the joints *a l* and *b r*, cutting the outſide of the rail at *l* and *r*; through the points *l*, *a*, *b*, *r*, draw perpendiculars *c C*, *a A*, *b B*, and *d r D*, cutting *a b* at *c*, *a*, *b*, *d*; from the points *a* and *b* make *a T* and *b B* reſpectively equal to *A a*, and *B Z*, *fig.* 2; through the points *T* and *B*, parallel to *a b*, draw *t C*, cutting *c L C* at *C*, and *d r D* at *v*; through the points *C* and *B* draw *C B D*; take any number of intermediate points *e*, *f*, *g*, at pleaſure, in the chord *a b*, and from theſe points draw lines *e E*, *f F*, *g G*, cutting *C B* at *E*, *F*, *G*; then from all the points *C*, *A*, *E*, *F*, *G*, *B*, *D*, draw lines perpendicular to *C D*; then make all the diſtances *E H*, *F I*, and *G K*, equal to their correſponding diſtances *e h*, *f i*, *g k*; and the diſtances *C L*, *A M*, *E N*, *F O*, *G P*, *B Q*, *D R*; then a curve being drawn through the points *A*, *H*, *I*, *K*, *B*, will form the inſide of the mould, and another curve being drawn through *L*, *M*, *N*, *O*, *P*, *Q*, *R*, will give the outſide of the mould; join the points *L A*, and *B R* will give the ends for a plumb or perpendicular joint to the plan of the ſtair, ſo the mould for this quarter will be completed.

In the ſame manner the other moulds for the rail will be found, by taking the heights *Z z*, *C y*, for the ſecond mould, and *Y y*, *D a* for the third; *x X*, 15 *w* for the fourth mould.

FIG. 3, ſhows the manner of drawing the plan of a rail of this kind with a pair of compaſſes.

Let *O A* be the radius of the conical fruſtum at the top of the rail, and *O n* the radius of the fruſtum at the bottom of the rail; divide the difference *A a*, into four equal parts; round

round the centre *O*, conſtruct a ſquare whoſe ſides are each equal to one of the four parts of *A a*, the centre *O* being the centre of the ſquare 1 2 3 4, and two of its ſides being parallel to *A O*; produce the ſides of the ſquare 1 2 3 4, towards *G*, *H*, *I*, *K*; take the radius *O A*, made leſs by half the ſide of the ſquare, and on the point 1, as a centre, deſcribe the quadrant *B C*, cutting 1 *G* at *B*, and 1 *H* at *C*; on 2 as a centre, with the diſtance 2 *C*, deſcribe the arc *C D*, cutting 2 *H* at *C*, and 2 *I* at *D*; on the point 3, with the diſtance 3 *D*, deſcribe the arc *D E*, cutting 3 *K* at *E*; laſtly, on 4, with the diſtance 4 *E*, deſcribe the arc *E F*, cutting 1 *G* at *F*, will complete the inſide of the plan of the rail near enough for any practice; then if *B G* be the thickneſs of the rail, the outſide of the rail *G*, *H*, *I*, *K*, will be completed by going round the centres 1 2 3 4, in the ſame order.

FIG. 4, ſhows the plan of a rail for a conical well-hole to three flights of ſtairs.

Note. The plan of theſe rails are the ſame curve as the ſpiral of Archimedis.

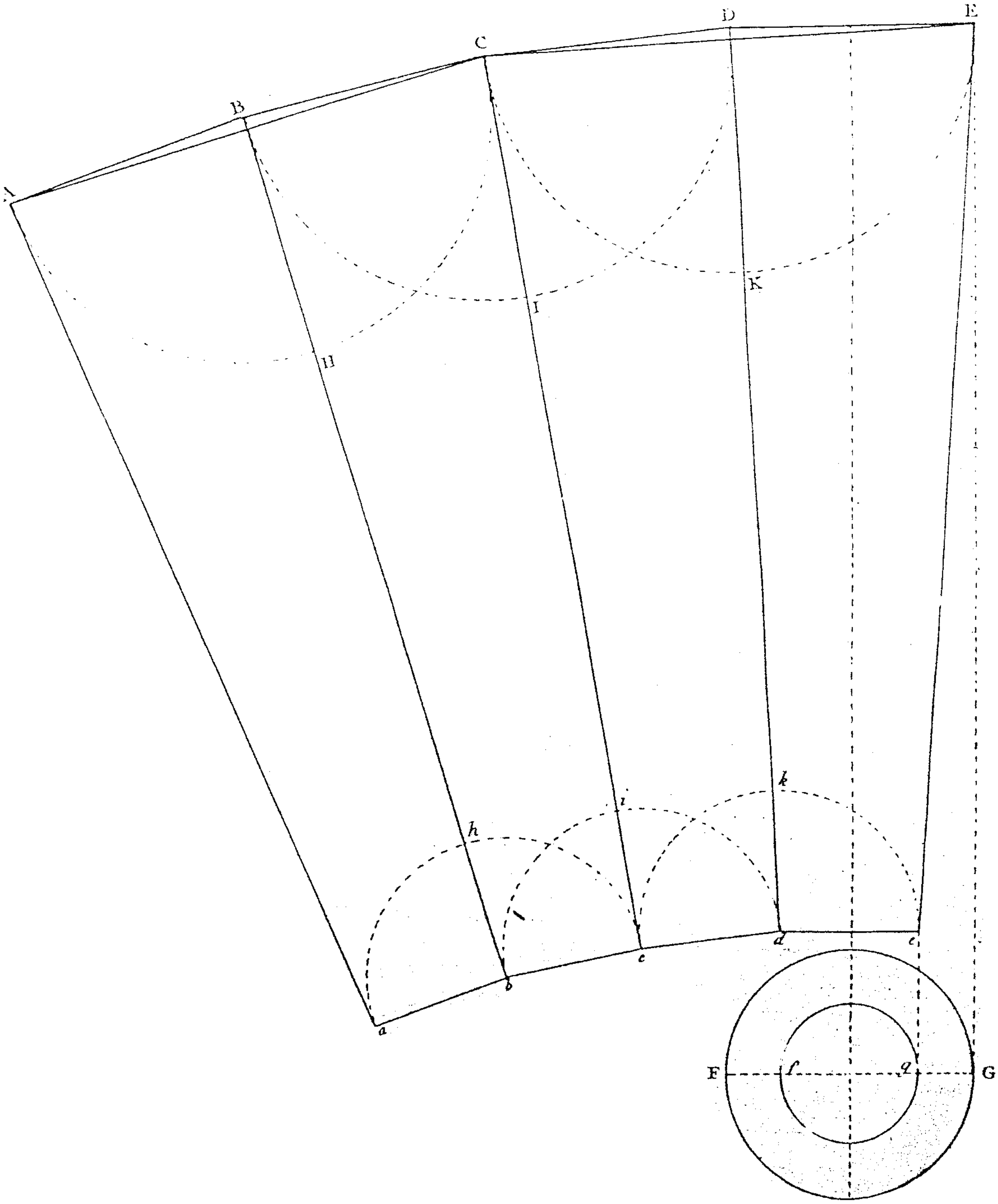
PLATE LXIII.

MOULDS.

How to find the moulds for making a hand rail in thickneſſes, when the well is the fruſtum of a cone.

Let *D E* and *d e* be the top and bottom diameters of the fruſtum, equal to *F G* and *f g* on the plan; and *D d*, *E e*, the ſlant ſides; on *D* as a centre, with the diſtance *D E*, deſcribe a circle *E K C*, cutting *D d* at *K*, and *D E* at *E*; make the arc *K C* equal to the arc *K E*, and on *d*, as a centre, with the diſtance *d c* deſcribe a circle cutting *D d* at *k* and *d e* at *e*; from *k* make the arc *k c* equal to the ark *k e*, through the points *C* and *c* draw the line *C c*; alſo through *D* and *E*, draw *D E*; then on *C*, as a centre, with the diſtance *C D* deſcribe an arc *D I B*, cutting *C c* at *I*, and *C D* at *D*; make the arc *I B* equal to the arc *I D*; on *c*, with the diſtance *c d*, deſcribe an arc *d i b*, cutting *C c* at *i*, and *c d* at *d*; make the arc *i b* equal to the arc *id*; join *C B*, *c b*, and *B b*, and proceed in this manner as far as may be thought neceſſary; then the points *A*, *B*, *C*, *D*, *E*, and *a*, *b*, *c*, *d*, *e*, will be in the circumferences of circles of which the vertex of the cone is the centre; a circle may be deſcribed round any three of theſe points by means of a lath, as is ſhown in plate 58, *fig.* 3. This is a neceſſary preparation for the next plate.

PLATE



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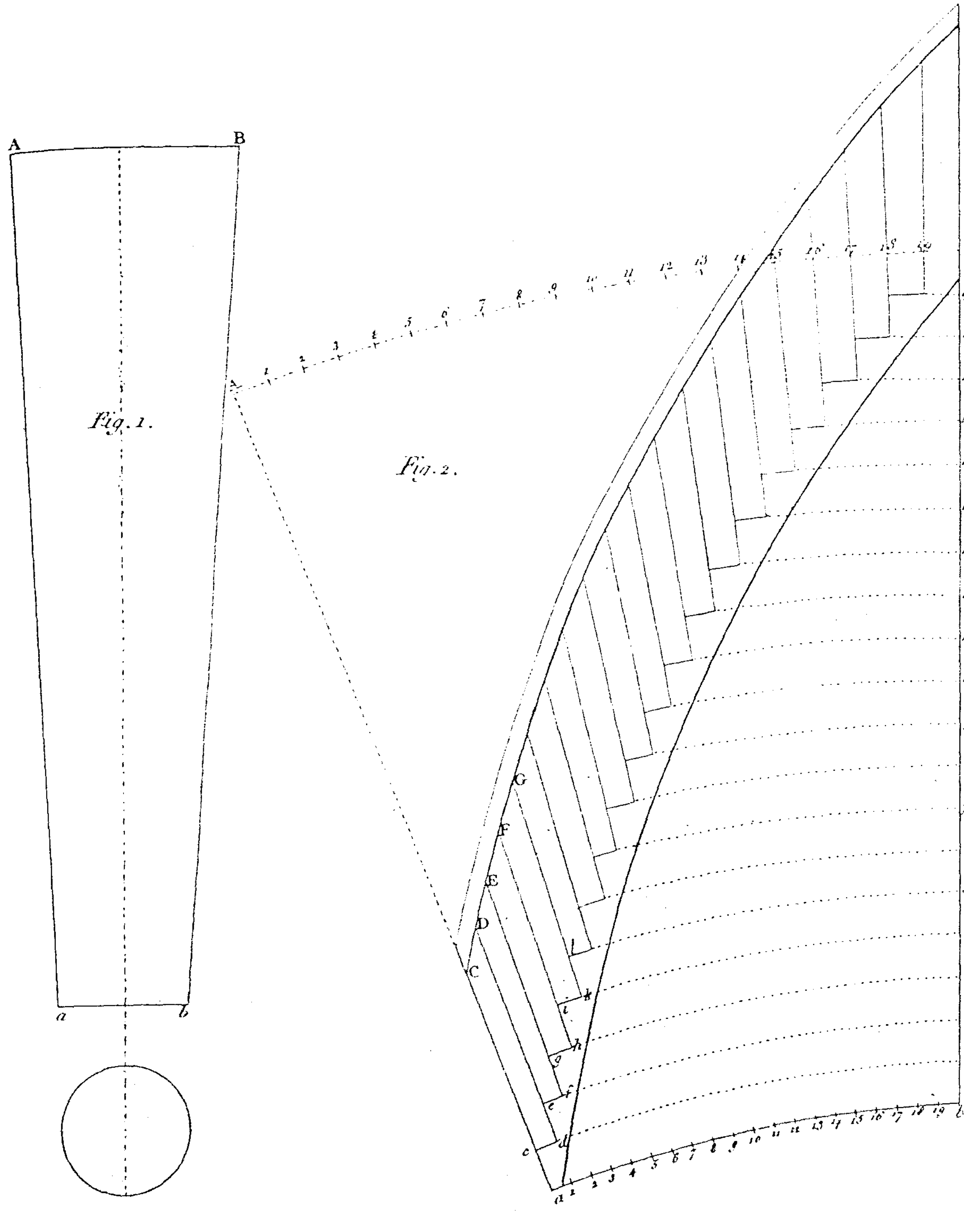

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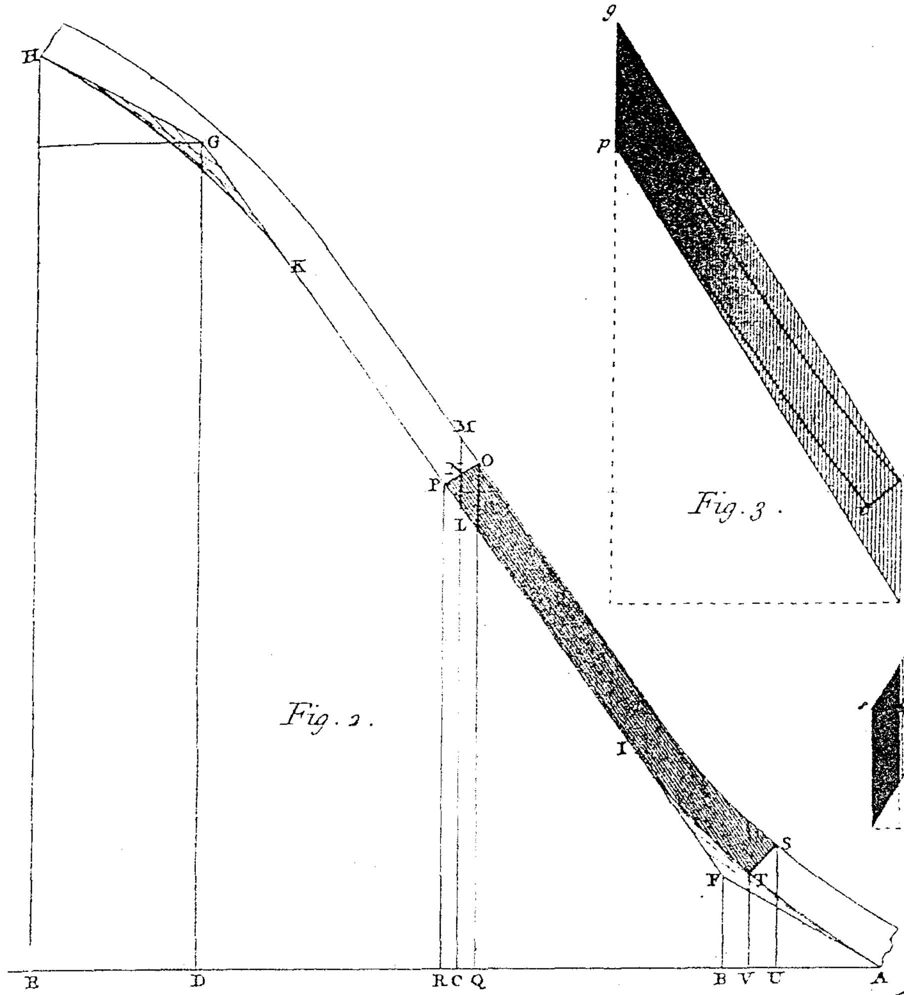

Fig. 2.

Fig. 3.

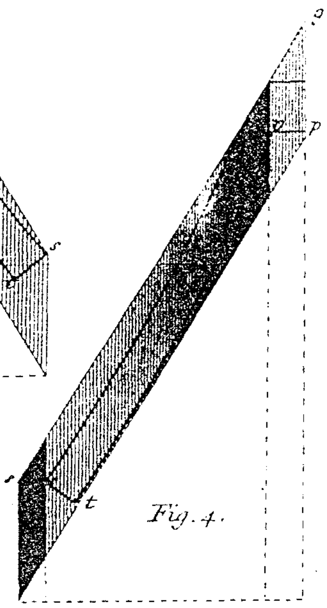

Fig. 4.

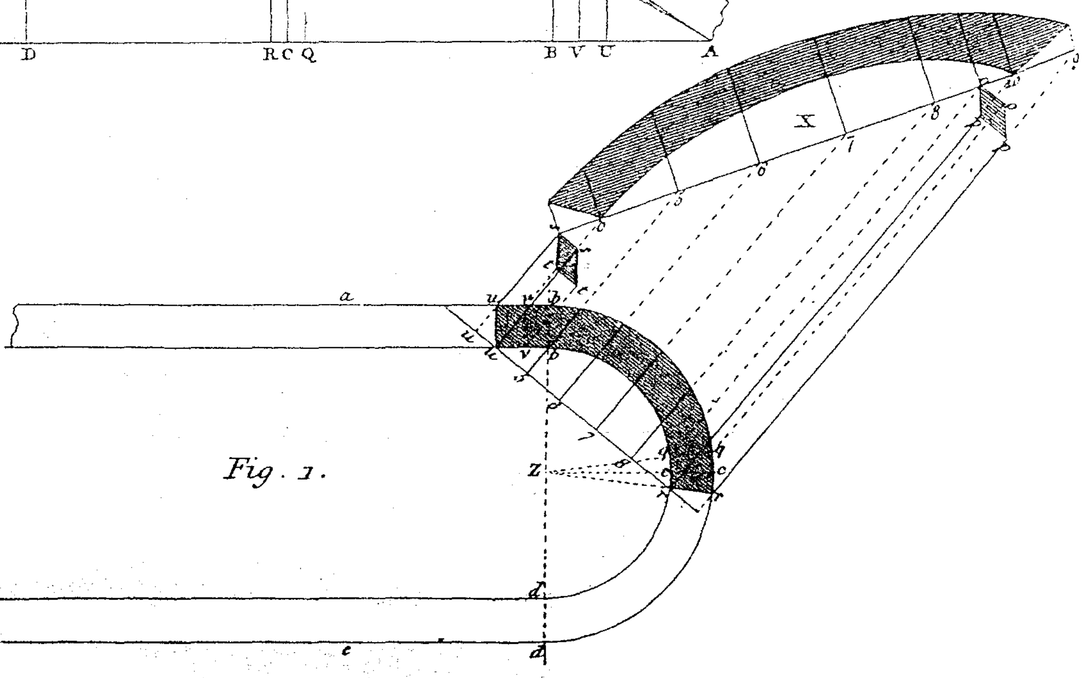

Fig. 1.

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PLATE LXIV.

Let *B b* be the ſlant ſide of the cone, containing twenty ſteps; *A B* and *a b* be two arcs found as in the laſt plate, by means of a lath, of which the vertex of the cone is their centre; divide *a A* and *b B*, each, into twenty parts or heights of ſteps, beginning at the bottom; then, with the ſame lath through each two correſponding points, draw circles by means of the before-mentioned lath; from *B* and *b*, make the arcs *B A* and *b a*, equal to the circumferences at the top and bottom of the fruſtum, *fig.* 1, whoſe diameters are *A B* and *a b*, and divide each of theſe circles into twenty equal parts, or treads, at 1, 2, 3, 4, &c. and 1, 2, 3, 4, &c. then *a c* will be the height of the firſt ſtep, and *d e* the height of the ſecond; by drawing a line from 1 to 1, in the ſame manner *f g*, *h i*, *k l*, &c. will be found by drawing lines between 2 2, 3 3, 4 4, &c. until you have got to the top at *B*. The ſteps being now compleated, the rail will eaſily be found as follows: Draw lines *c C*, *e D*, *g E*, *c F*, *e G*, &c. through the points 1, 1. 2, 2. 3, 3. 4, 4. which will all tend to the vextex of the cone; then make all the heights *c C*, *e D*, *g E*, *h F*, *f G*, &c. equal to the height of the baliſters, and draw a curve through all the points; *C*, *D*, *E*, *F*, *G*, will give the under edge of the falling mould, and a line being drawn above, parallel to, at the thickneſs of the rail, will give the upper edge, which will be a mould for one of the thickneſſes.

PLATE LXV.

To find the moulds for making butt joints for a rail, when got out of the ſolid.

Let *fig.* 1, be the plan of the rail *b c d*, and *b c d* the two ſides of the circular part; *a b*, and *d e*, the breadths of two common ſteps at the beginning and end of the winders; make the whole ſtretch-out of the ſtrieght line *A B C D E*, *fig.* 2, equal to *a b c d e*, round the outſide going upwards, *fig.* 1; that is, make *A B*, in *fig.* 2, equal to *a.b*, *fig.* 1; the laſt common ſtep in the aſcent before the winders; *B C D* in *fig.* 2, equal to the circumference of the ſemi-circular part *b c d*, *fig.* 1, and *D E*, in *fig.* 2, equal to *d e*; on the outſide, *fig.* 1, the firſt common ſtep immediately after aſcending the winders, draw the lines *B F*, *D G*, and *E H*, perpendicular to *A E*; make *B F* equal to the height of one ſtep; make *D G* one ſtep higher than the number of winders that is in this example; ſuppoſe the circular part to contain eight winders, then *D G* will be equal to the height of nine ſteps; make *E H* equal to the height of ten ſteps; then join *A F*, *F G*, *G H*, and deſcribe the parabolical parts *A I*, and *K H*, and the under edge of the falling mould will be completed; the upper edge will be formed by drawing a line parallel to it, equal to the thickneſs of the rail.

Bifect the ftretch-out of the circular part *B D*, at *C*; from *C* draw *C M* perpendicular to *A E*, cutting both edges of the falling mould at *L* and *M*; bifect *L M* at *N*, and through *N* draw *O P* at right angles to the falling mould, cutting it at *O* and *P*; through the points *O* and *P*, draw *O Q* and *P R*, each perpendicular to *A E*, cutting *A E* at *Q* and *R*, let *S T* be the joint on the ftreight part; then from the points *S* and *T*, draw *S U*, and *T V* perpendicular to *A E*, cutting it at *U* and *V*; then take the diftances *C R* and *C Q*, in *fig.* 2, and apply them in the middle of the circular part, *fig.* 1, from *c* to *r*, and from *c* to *q*, and draw to the centre *r Z*, and *q Z*, cutting the infide of the rail at *r* and *q*; alfo take the diftances *B V* and *B U*, *fig.* 2, and apply them from *b* to *v*, and from *b* to *u*, *fig.* 1; then draw *v v*, and *u u* at right angles to the rail, cutting the other fide at *v* and *u*; then through the points *u* and *r* on the infide of the rail, *fig.* 1, draw the chord *u r*; then from all the points *u*, *u*, *v*, *v*, *q*, *q*, and *r*, *r*, draw lines *u u s*, *u s*, *v t*, *v t*, and *q o*, &c. each perpendicular to the chord line *u r*; then complete the fections of the rail *t t s s*, and *o o p p*, as are fhown at the fhadowed parts, and draw the chord line *s o* to touch thefe fections without cutting them. Then take any number of intermediate points, as 5, 6, 7, 8, in the chord *u r*, and draw the lines 5 5, 6, 6, 7 7, 8 8, perpendicular to *u r*, cutting the chord of the face mould *s o*, at the points 5, 6, 7, 8; continue the lines *u s*, and *r p*, till they cut the chord line of the face mould *s o*, at 0 and 9; through all the points *s*, *o*, 5, 6, 7, 8, 0, 10, 9, draw lines perpendicular to the chord of the face mould *s o*, for ordinates, points being found in each of them correfponding to thefe; on the plan and lines being traced through thefe points, the face mould *X* will be completed in the ufual manner.

N. B. The fmall letters on the fections of the face mould, and fimilar capital letters of the falling mould, fhew correfponding places in each.

How to cut the joints.

The ftuff muft firft be cut out by the face mould, and the joints made exactly plumb, according to the face mould, as is fhown by *fig.* 3 and 4.

To make this appear plain, of *fig.* 3 and 4, are different views of the folid rail got out by the face mould *X*. *Fig.* 3, fhows the top and convex fide of the piece that is to make the rail; take the diftance 9 *p* from the chord line of the face mould down the perpendicular, *fig.* 1, and fet it from 9 to *p* in *fig.* 3. Then apply the fhadowed part of the falling mould at *fig.* 2, which is to correfpond to the block of the rail, *fig.* 3, that is, apply the point *S*, the upper edge of the lower end of the falling mould at *fig.* 2, to the point *s* at *fig.* 3, and bend the falling mould round until the point *P*, the lower edge of the upper end of the falling mould, coincide with the point *p*; draw a line all round by the falling mould, it will fhow how to cut off the ends of the rail, and will alfo give the upper and lower edge of the rail. *Fig.* 4 fhows the concave fide of the piece, in order to fhow the ends; having fimilar letters of reference as before. From *s*, in *fig.* 4, draw *s s* at right angles to *s b*; then cut off the end through the line *s s*, as is fhown at *fig.* 3, and through the points *s*, *t*, as is fhown at *fig.* 4. The upper joint will be found in the fame manner, that is, by drawing the line *p p* at right angles to 9 *p*, then cut

cut off the end through the line *p p*, in *fig*. 4, and through *p o*, as is ſhown in the other view, *fig*. 3. If great accuracy is required in ſquaring the rail, make an inſide falling mould, which apply the under edge of the upper end to the point *p* in *fig*. 4, and the upper edge of the lower end of the falling mould to the point *s*, and draw lines above and below by the two edges of the falling mould, and it will give the form of the upper and under edges of the rail. By this method of proceeding, the workman will be enabled to cut out the ſtuff of a hand rail with very great accuracy.

Addition to the Deſcription of PLATE XXIX.

For making of rule joint, *fig*. 2, 3, obſerve that if there is not a ſpace about one-ſixteenth of an inch between the ſtraps, when the hinge is ſhut, it will be neceſſary that no light be ſeen through the joint, to work the ſtile B on the outſide, half a ſixteenth further on than exactly ſquare, to accommodate which you muſt take as much from the ſtile A.

But if there is the requiſite ſpace between the ſtraps, then the above obſervation does not apply, and it is better the hinge ſhould be thus.

EXAMPLES

OF

ROOFS

WHICH ARE BUILT.

IN the Preface I have ſtated my reaſons for giving theſe Examples; it is only neceſſary here for me to ſay, that the following are taken from my own actual meaſurements, viz. St. Paul's Cathedral, Iſlington Church, St. Martin's Church, the new roof of Covent-Garden Church, the Chapel of Greenwich-Hoſpital, and the Tower of the York-Buildings Water-works. The old roof of Covent-Garden Church I have been favoured with from a Gentleman's drawing, who meaſured it at the time of the repairs in 1795.

The roofs of Drury-Lane and Birmingham Theatres were copied, by permiſſion, from the original drawings.

PLATE LXVI. AND LXVII.

Of the Dome of St. Paul's Cathedral, London.

A A a a A A, a dome of brick, two bricks thick, which, as it riſes every five feet, has a courſe of excellent brick of 18 inches long, bonding through the whole thickneſs. This dome, it may be proper to obſerve, was turned upon a centre, which was laid without any ſtandards from below to ſupport it. Every ſtory of the ſcaffolding being circular, and the ends of the ledgers meeting as ſo many rings, and truly wrought, it ſupported itſelf; and as it was both centering and ſcaffolding it remained for the uſe of the painter, there being a ſpace of 12 feet between it and the dome. This machine was original of the kind.

Although the dome wants no butment, yet, for greater caution, it is hooped with iron in this manner: a channel is cut in the bandage of Portland ſtone, in which is laid a double chain of iron, ſtrongly linked together at every ten feet, and the whole filled up with lead.

This dome was afterwards painted in a moſt beautiful ſtyle by the celebrated *Sir James Thornhill*.

B B b b B B, is a cone built with bricks, one foot ſix inches in thickneſs, and is alſo plaiſtered and painted; part of this cone may be ſeen from the flooring of the church through the opening at *a a*, the top of the interior dome.

The timber work is well ſupported by the brick cone *B B b*; the horizontal or hammer beams *C C*, *D D*, *E E*, *F F*, being curiouſly tied into the corbels *G*, *H*, *I*, *K*, with iron cramps, which are well bedded into the corbels with lead, and bolted to the hammer beams.

Between the truſſes of the roof is carried the ſtairs which lead to the Golden Gallery at the top of the dome.

The dome is boarded from the baſe upwards, and therefore the ribs are fixed horizontal at near diſtances to each other, in the ſame manner as is ſhown in my example of a domical roof, Plate XIII. of this work, where the ſides of all the ribs ſtand in planes tending to the centre of the dome. The ſcantling of the curve rib of the truſs, is 10 inches by 11½ at the bottom, and 6 inches by 6 at the top.

The ſides of the dome are ſegments of circles, the centres of which are marked in the plate, and which, if continued, would meet at the top, and form a pointed arch.

On the top of the dome is built a cupola of Portland ſtone, which is twenty-one feet diameter, and near ſixty-four feet high, ſupported by the cone, and by the timber work of the truſſes.

The conſtruction of this dome is an admirable example of the ſkill and great mathematical knowledge of *Sir Chriſtopher Wren*.

PLATE

Carpentry for Roofs. St. Pauls Cathedral.

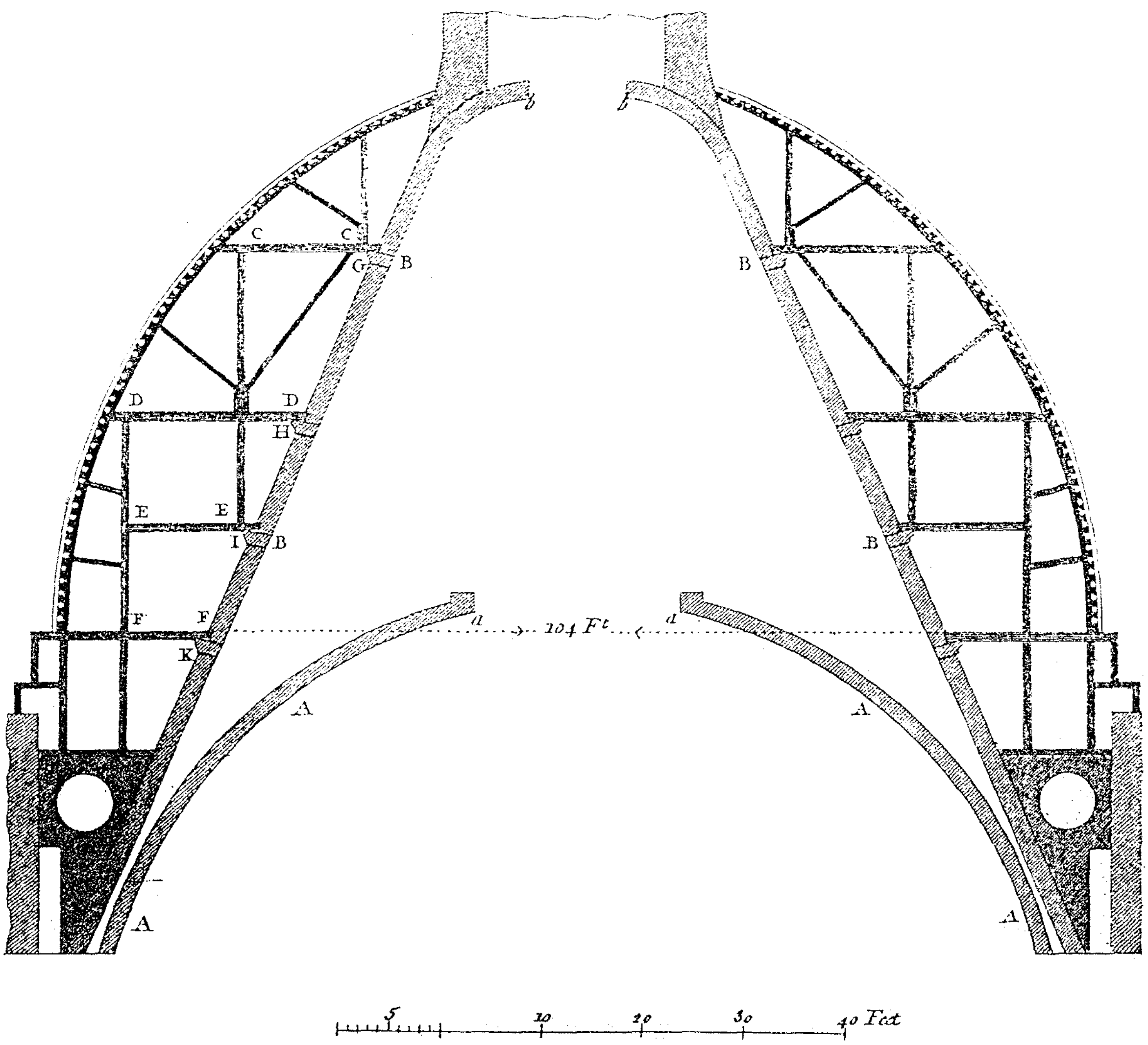

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PLATE LXVII.

A trufs of the dome to a larger fcale, fhowing the manner in which the iron cramps are fixed to the corbels and bolted to the hammer beams. The horizontal bars, *a*, *b*, *c*, *d*, are about four inches fquare, and about the fame in number as are fhown in the plate.

A a, part of the ftone work which fupports the fteps or breaks, immediately under the curve of the dome.

Scantling of the timbers.

A Poft — —	7 in. by 7		*M* Strut — —	5 in. by 8
B Strut — —	5 in. by 8		*N* Hammer beam —	8 in. by $11\frac{1}{2}$
C Hammer beam —	8 in. by $7\frac{3}{4}$		*O* Poft — —	10 in. by $11\frac{1}{2}$
D Poft — —	$8\frac{1}{2}$ in. by $8\frac{1}{2}$		*P* Poft fupporting the curve rib of the dome —	10 in. by $11\frac{1}{2}$
and 15 by $8\frac{1}{2}$ at bottom.				
E Brace — —	6 in. by 8		*Q, Q, Q, Q*, Curve rib of the dome — —	10 in. by $11\frac{1}{2}$
F Strut — —	5 in. by 8		at bottom, and 6 in. by 6 at top.	
G Hammer beam —	8 in. by 10			
H Poft — —	$8\frac{3}{4}$ in. by $9\frac{1}{2}$			
I Poft — —	10 in. by $9\frac{1}{2}$		*a*, *b*, *c*, *d*, *e*, &c. fmall horizontal rafters —	4 in. by 4
K Strut — —	5 in. by 8			
L Hammer beam —	8 in. by 10		*R* Wall plate —	8 in. by 12

The diameter of the dome is 104 feet, and in the circumference there are 32 truffes. It may be obferved that the fcantling of none of the timbers in this dome is fo great, as in many churches.

PLATE LXVIII.

Of the old and new Roofs of St. Paul's Church, Covent Garden.

The beautiful portico of this Church is of the Tufcan order, and is executed according to the rules of Vitruvius, who fays, that the mutules or cantilivers of the cornice ought to project a quarter of the height of the columns, which requires the roof to have a peculiar conftruction, which is fhewn in thefe truffes.

FIG. 1, the roof to the Church, as executed by *Inigo Jones*, and which was confumed by the unfortunate fire in 1795.

PLATE

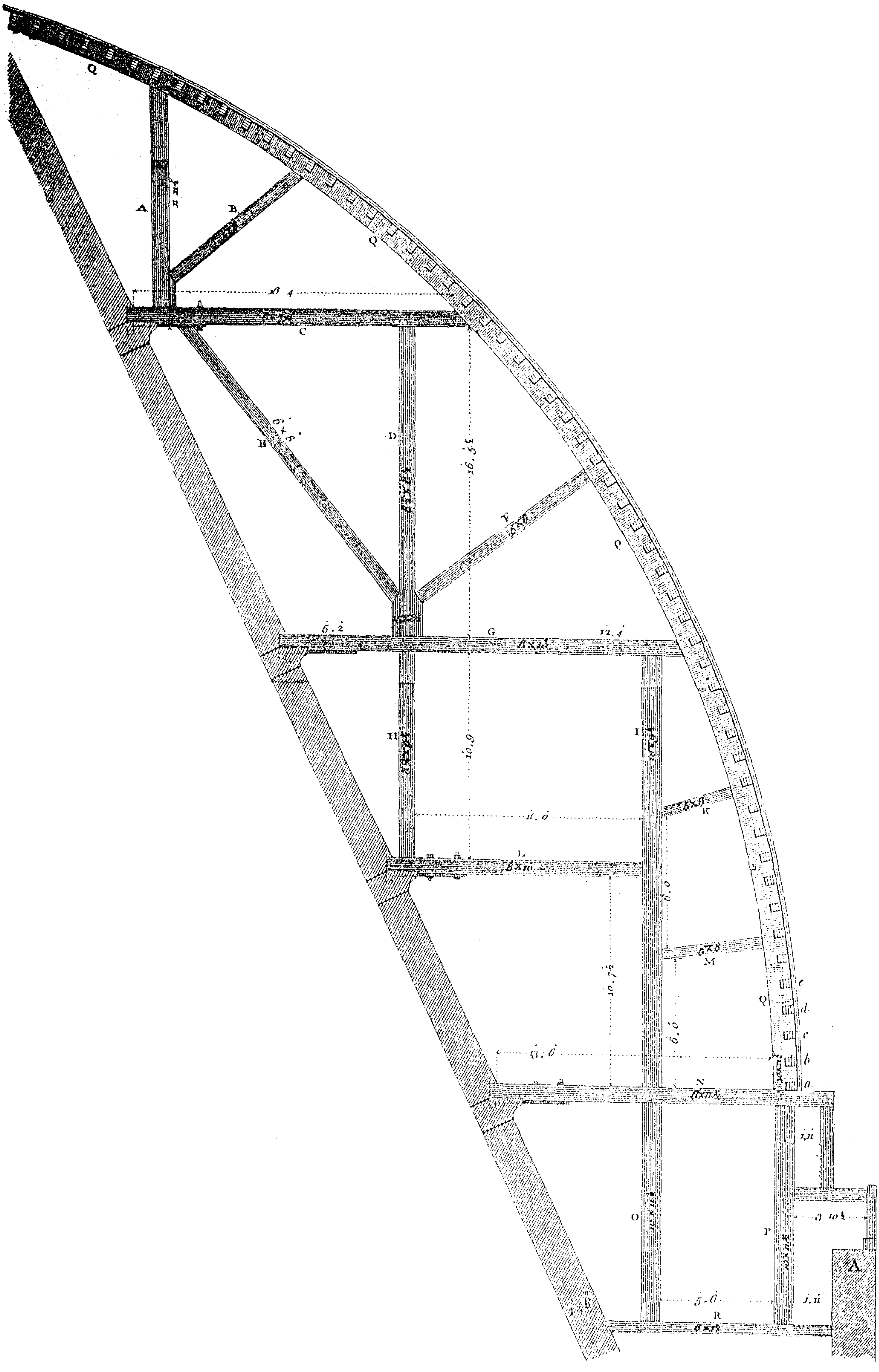

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PLATE LXVIII.

FIG. 1. *The old roof.*

	Scantlings.
A A, the tie beam projecting over each wall about ſeven feet, which is the projecture of the mutules, being in length about 72 feet, and 50 feet 2 inches in the clear of the walls — —	16 in. by 12
B B, the king poſt — — —	12 in. ſquare
C C, *D D*, *E E*, braces halved into each other, and alſo into the king poſt *B B* — — — —	12 in. by 8
F F, one of the queen poſts — — —	12 in. by 12
G, one of the ſtuds — — —	10 in. by 10
H H, one of the principal rafters — —	12 in. by 10
I, one of the principal braces — — —	12 in. by 8
i i i i i, purlines — — —	12 in. by 10
k k, common rafter — — —	6 in. by 4

The diſtance between the truſſes about 10 feet 6 inches

FIG. 2. *Truſs for the new roof.*

	Scantlings.
A A, the tie beam, which cambers 6 inches on the clear of the church; the length of the beam being the ſame as in the old truſs — —	16 in. by 12
B B, one of the queen poſts (in the ſmall part) — —	$8\frac{1}{2}$ in. ſquare.
C, collar beam — — —	10 in. by 8
D, king poſt (14 in. at the jogle) — —	$8\frac{1}{2}$ in. ſquare.
E, brace — — —	8 in. by $7\frac{1}{2}$
F F, one of the principal braces, or an auxiliary to the principal rafter in order to ſtrain the beam *A A*, and keep it from being bent over the walls by the weight of the roof (at top $8\frac{1}{2}$ in. ſquare) — at bottom	10 in. by $8\frac{1}{2}$
g g, ſtuds on one ſide of the roof in order to ſtrengthen the bearing of the principal rafter — — —	8 in. ſquare.
H H, the principal rafter ſupported by the ſtuds *g*, *g*, queen poſt *B B*, and king poſt *D* (at top $8\frac{1}{2}$ ſquare) — — at bottom	10 in. by $8\frac{1}{2}$
i, *i*, the purlines on one ſide, ſupporting the ſmall rafter *K K* —	9 in. by $6\frac{1}{2}$
K K, the ſmall rafters — — —	6 in. by $3\frac{1}{2}$
L L, wall plates — — —	12 in. by 10

The dotted lines in the middle compartment ſhows the manner in which this roof is framed under the cupola; the diſtance of the truſs is about 10 feet 6 inches, as in the old roof.

At

Carpentry for Roofs *Covent Garden Church.*

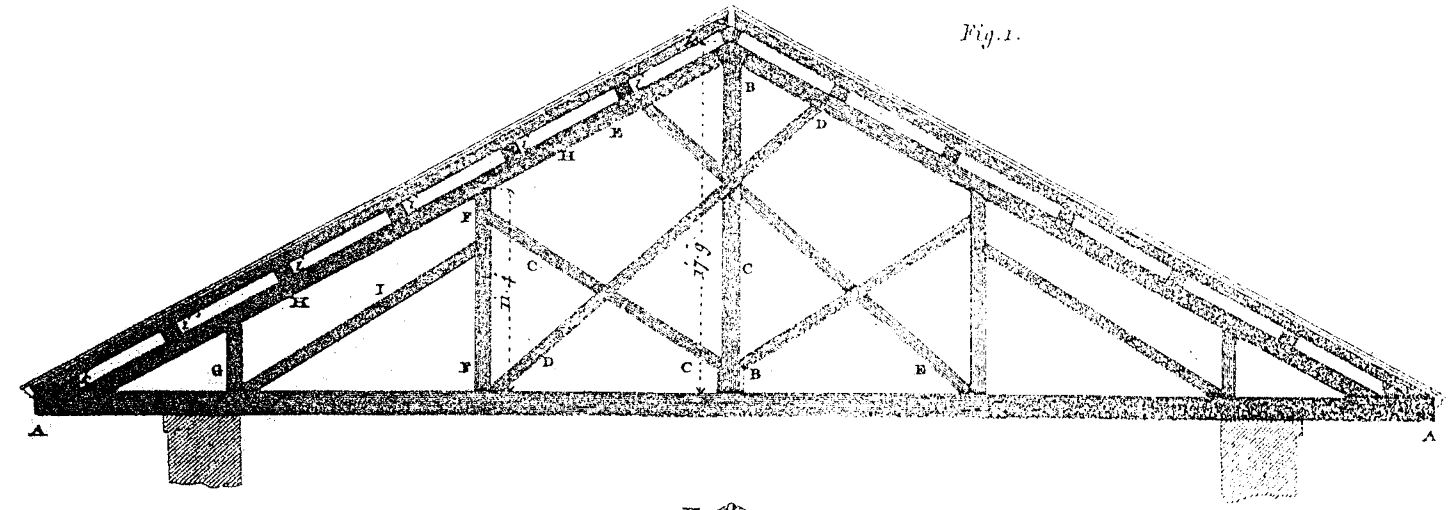

Fig. 1.

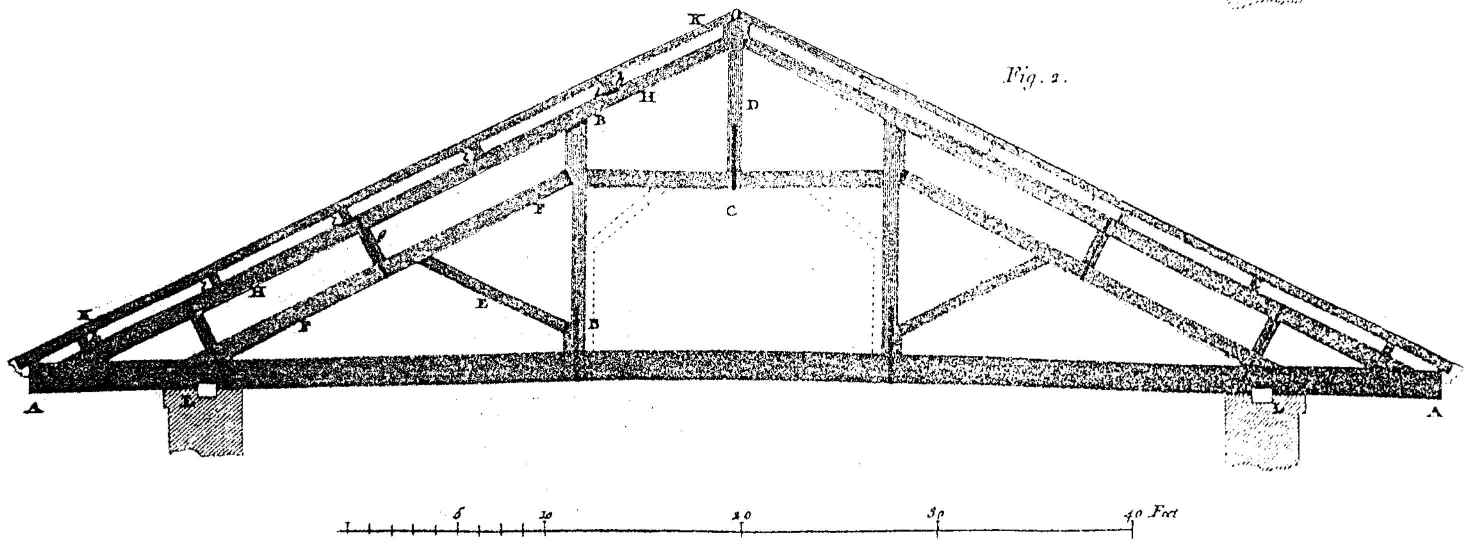

Fig. 2.

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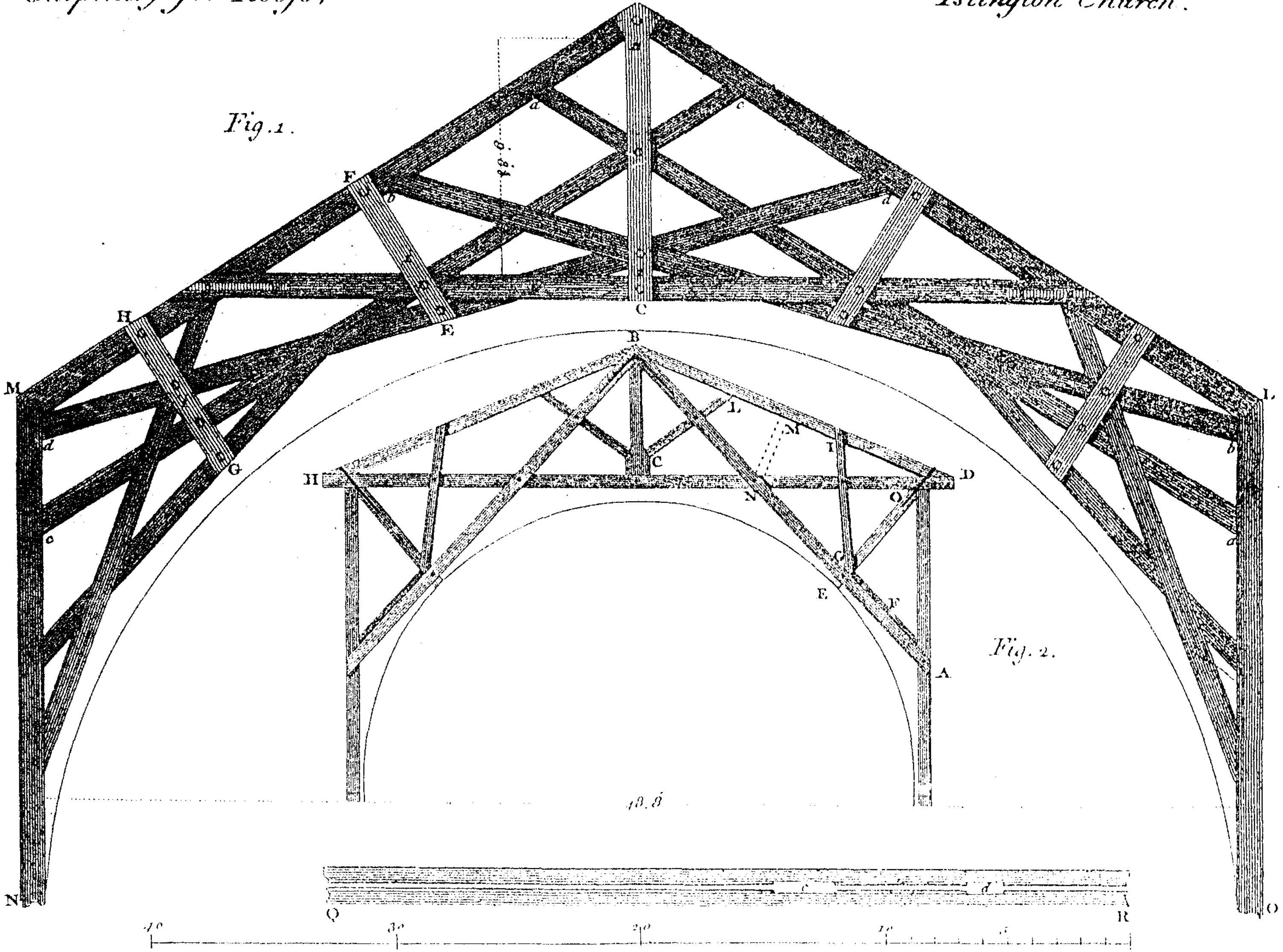
Carpentry for Roofs.

Islington Church.



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At firft fight one would be led to think the timbers of the old roof are placed fo as to make it very ftrong; but the want of proper butments, or joggles, at the bottom of the queen poft, together with the frequent cutting or halving the pieces together, render it altogether very infirm, and I think much inferior to the modern roof, *fig.* 2; where every timber performs its proper office, in ftrengthening the roof, and in refifting the action of the wind, the weight of fnow, &c. It muft alfo be obferved in favour of the modern improvements in carpentry, that a trufs of the old roof contains about 273 folid feet of timber, whereas the new roof contains only about 198 feet in each trufs.

The prefent roof was put up in 1796. Mr. Hardwick, Architect. Mr. Wapfhott, Carpenter.

PLATE LXIX.

Of the roof of Iflington Church.

The fpan of this building is forty-eight feet eight inches, within the walls; the length of the beam *I K*, is thirty-one feet three inches from the infide of one rafter to the infide of the other, which is in two thickneffes, as is fhown by *fig. Q R*; *c* and *d* reprefents the fpace cut out to receive the braces.

The braces *a a*, *b b*, *c c*, *d d*, are halved into each other, and are $11\frac{1}{4}$ inches broad, and feven inches thick; the king poft *C D*, and the pieces *E F* and *G H*, are in two thickneffes, each piece being let in on each fide of the trufs into the braces, leaving a fmall fpace between them, and are all bolted together at the interfection of the braces.

The pieces *C D*, *E F*, *G H*, are each 1 foot broad; the thickneffes, together with the fpace between them, is one foot four inches; the diftance between the truffes is 12 feet.

I should be cautious of ufing this kind of conftruction, viz. coveing the ceiling fo much into the roof. Had the collar beam *I K*, beeu placed as low as *M L*, fo as to have taken the whole fpan to the walls, the trufs would have been more fafe, and have taken lefs timber.

This roof was built about the year 1752; Mr. Dowbiggin, Architect, Mr. Stimfon, Carpenter.

The conftruction of this roof is ingenious but complicated. It takes a great quantity of timbers, and the frequent interfection and halving of which is very objectionable. The timbers are too much parallel to each other, producing only quadrilateral forms, which are always liable to revolve at the angles; whereas the ftrongeft poffible conftruction for a roof muft be fought in a triangle; and the timbers fo placed, or a roof conftructed on fuch principles, that is, with feweft quadrilaterals, will certainly bet he ftrongeft poffible: With thefe confiderations and maxims, and with due refpect to the roof before us, I have fhewn an example, *fig.* 2, fuited to a fimilar purpofe, and which muft be confidered as evidently ftronger, and as taking much lefs timber.

FIG. 2. This trufs is conftructed fo as to have one, two, or three purlines between the principal rafters, as circumftances may require: if only one purline is required, the proper place will be at *M*, in the middle of the rafter, with the butment at *N*, interfecting the principal brace and the tie beam. In this cafe the braces *G O*, *G I*, *C L*, may be omitted, which will render the trufs more fimple, and yet ftrong enough.

If two purlines are ufed, they of courfe will be placed over the braces *I* and *L*.

If three purlines are requifite, the rafter *D B*, ought to be divided into four equal parts and the braces *I*, *M*, *L*, fhould then be immediately under the purlines; thus every crofs ftrain will be thrown off the timbers, and every other ftrain which they receive laterally, will be from their own weight only; wherefore the timbers may be very flight and yet fufficiently ftrong.

The brace *A B* is double, bolted together at *A*, and ftrongly united by an iron ftrap to the other brace at the point *B*, where alfo they are bolted together through the head of the king poft: The rafters *D B*, and *B H*, may be ftrongly united by an iron ftrap over their tops.

The brace *C L* runs between the double brace *A B*, to which it is bolted at the interfection. The piece *E O* is faftened to the principal rafter and the tie beam by an iron ftrap, which ftrongly unites the three together. The brace *G I* is double, one half on each fide the brace *E O*, the tie-beam, and the rafter, to each of which it is bolted at the feveral interfections. The butment of this brace is fecured by the ftraining-piece *F*.

The pitch of this roof may be very low, even less than that of *fig.* 1, and yet be fufficiently ftrong: by fo low a pitch, the beauty of the building will be increafed; indeed it may with propriety be adapted to the proportion of a pediment to a portico, if required.

PLATE LXX.

Of the roof of St. Martin's Church.

FIG. 1, the whole trufs entire.

FIG. 2, half of the fame to a larger fcale; fhewing the fcantlings, lengths and bearings of the timbers.

The breadth of this building, within the walls, is about fixty-nine feet; the breadth of the fide ailes, reckoning from the centre of the columns to the walls is nearly fourteen feet five inches and a half; the breadth of the middle ailes, from centre to centre of the columns is about thirty-nine feet eleven inches. The form and manner of framing this roof, according to the extent and height, is judicious; but the fcantling of the timbers is much more than fufficient to refift the weight of the covering, force of the wind, &c. The brace *A B*, *fig.* 2, might have been omitted; it anfwers no purpofe to the ftrength of the roof, as the upright poft, which it feemingly fupports, is upheld by the column, which will prevent it from defcending; this roof is well and fufficiently braced throughout, fo that there is no danger of fwerving either on one fide or the other.

The church was built about the year 1721. Mr. John Gibbs, Architect.

Scantlings.

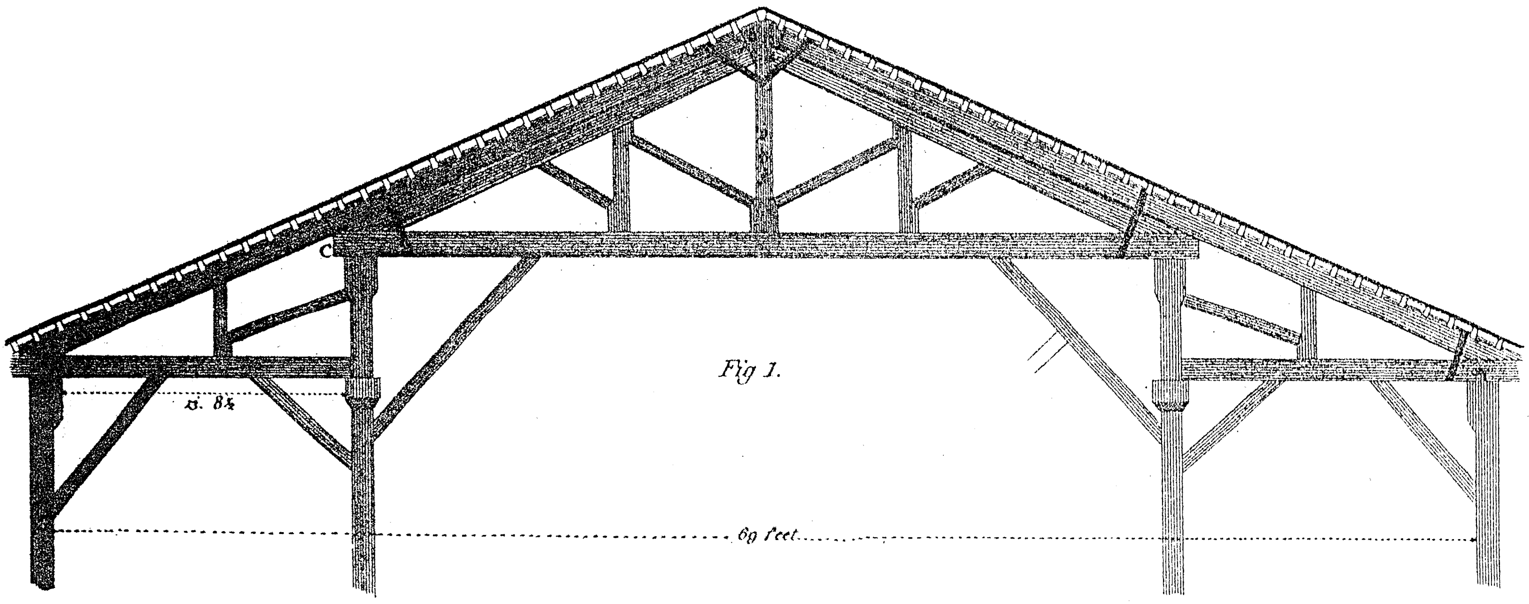

Fig. 1.

5 10 20 30 40 Feet

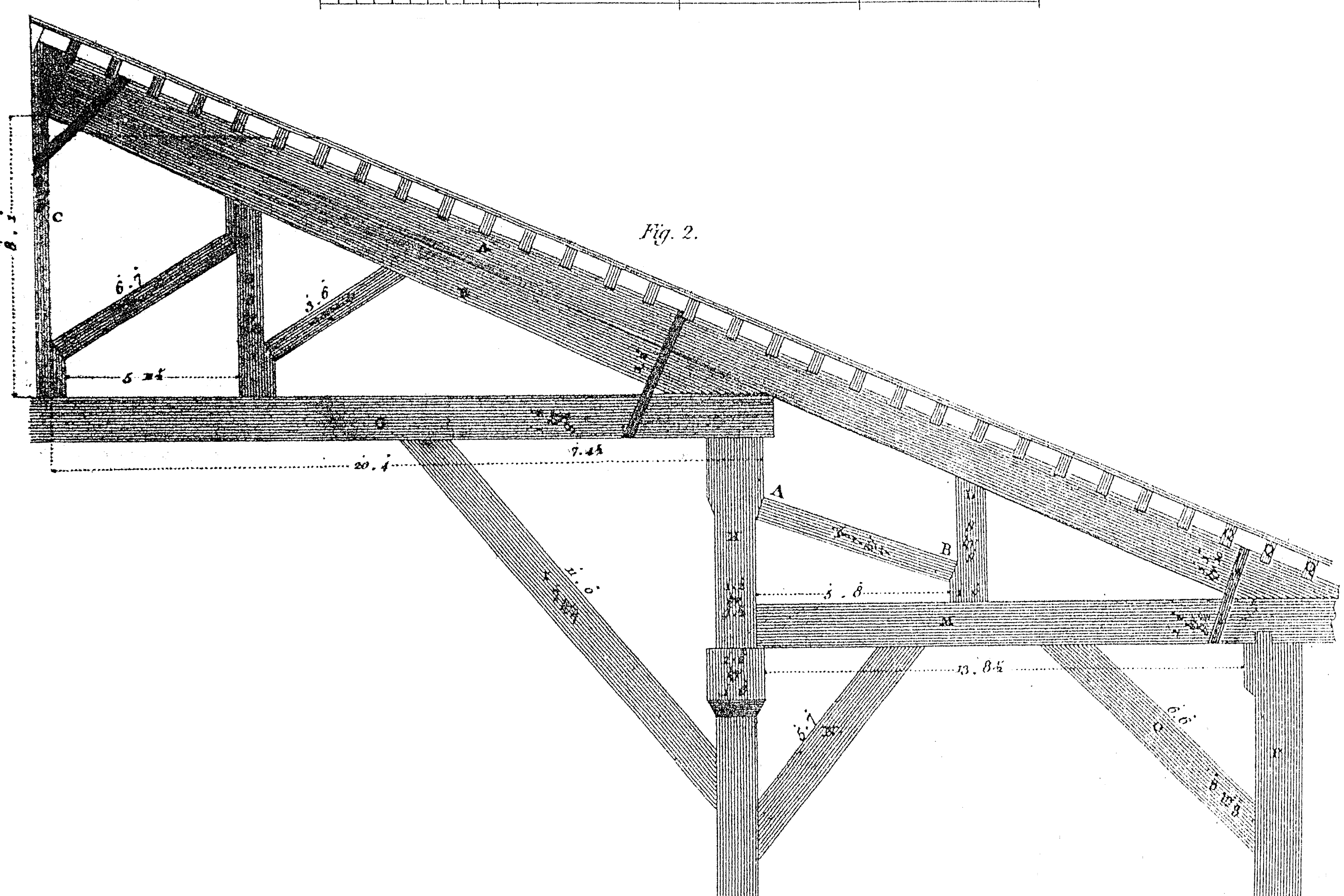

Fig. 2.

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Chapel of Greenwich Hospital

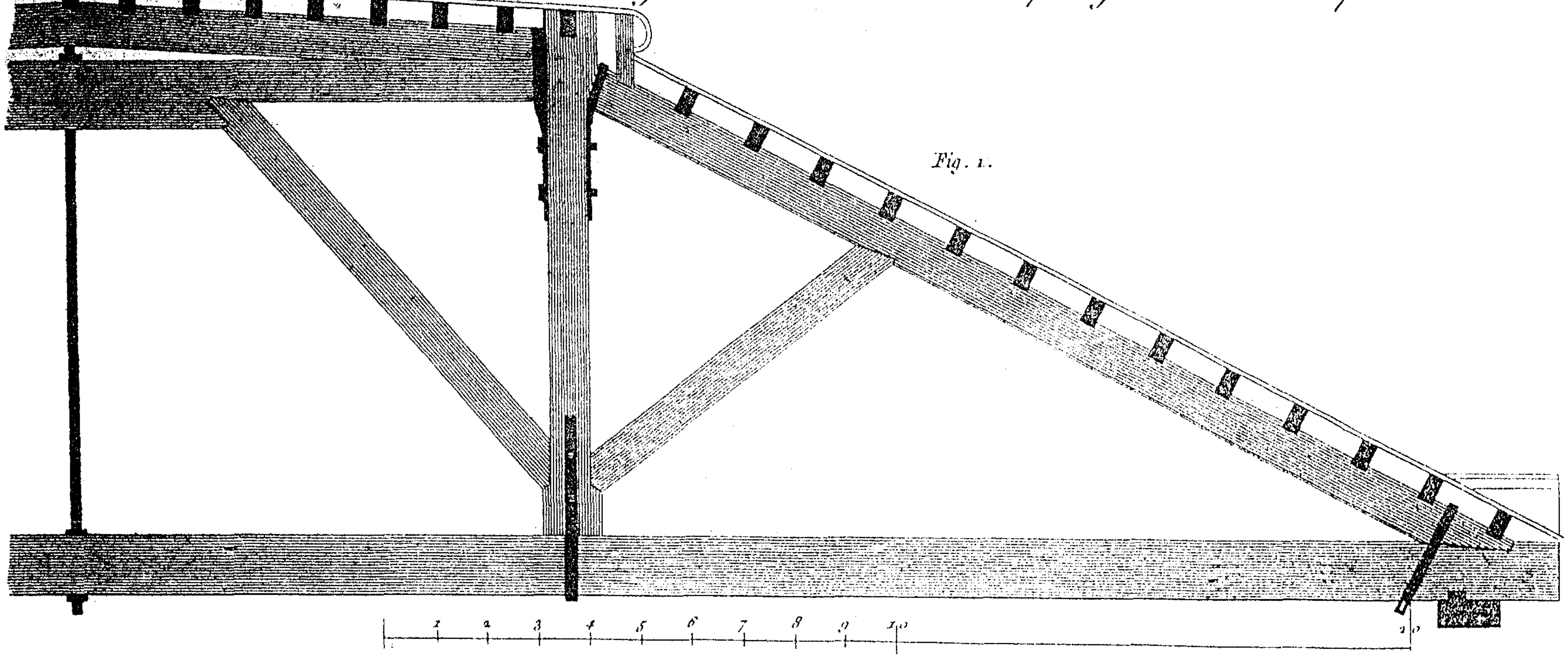

Fig. 1.

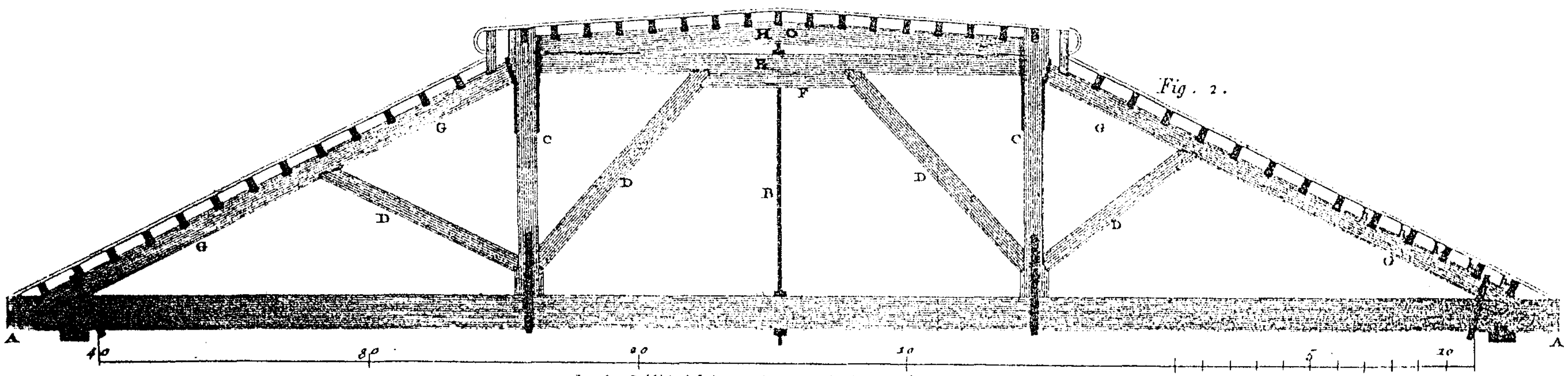

Fig. 2.

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Scantlings.

A, principal rafter - 13 in. by 10 at bottom, and 11 by 10 at top.	
B, principal brace - 14 in. by 10 at bottom, and 11 by 10 at top.	
C, king poſt - - 9 in. by 9	
D, ſtrut - - - 7 in. by $7\frac{1}{2}$	
E, queen poſt - - 8 in. by $9\frac{1}{2}$	
F, ſtrut - - - 7 in. by 7	
G, collar beam - - 14 in. by $9\frac{1}{2}$	
H, poſt over the column -	14 in. by $9\frac{1}{2}$
I, brace - - -	7 in. by 7
K, brace - - -	7 in. by 7
L, poſt - - -	8 in. by 9
M, hammer beam -	14 in. by $9\frac{1}{2}$
N, brace - - -	8 in. by 8
O, brace - - -	8 in. by 8
P, poſt in the wall	
Q, *Q*, *Q*, horizontal rafters	4 in. by 6

PLATE LXXI.

Of the Roof of the Chapel of the Royal Hoſpital at Greenwich.

After the fire at the Hoſpital in 1779, which did conſiderable damage to the Chapel and to the wing, it became neceſſary nearly to rebuild the whole of the Chapel, Mr. James Stuart being then ſurveyor; under his eye and care it received its preſent beautiful decorations. The roof, Pl. 71, was conſtructed by Mr. Samuel Wyatt, about 1785.

The roof is flat on the top, and the conſtruction is perhaps as ſtrong and ſimple as could be contrived for a platform; the king poſt is of iron, and the joints are well ſecured by iron ſtraps. It extends 51 feet in the clear and is a good example, materially varying from the general form of roofs.

Scantlings.

A A, the tie beam, the whole length is 57 feet, and the clear within the walls of the chapel is 51 feet - - -	14 in. by 12
B, an iron king poſt -	2 in. ſquare
C, *C*, queen poſts - -	9 in. by 12
D, *D*, *D*, *D*, braces -	9 in. by 7
E, collar beam - -	10 in. by 7
F, ſtraining piece - -	6 in. by 7
G G, *G G*, the principal rafters	10 in. by 7
h, *h*, *h*, *h*, &c. common rafters laying in a horizontal direction	4 in. by 6
H, a camber beam supporting the platform - -	9 in. by 7

The diſtance between the truſſes is about 7 feet.

PLATE LXXII.

Of the Roof of Drury-Lane Theatre.

This roof has certainly great merit, the conſtruction is ſimple, and the accommodations the moſt ample poſſible. By dividing the breadth of the building into three parts the roof is kept low, and the ſcantling of the timbers is much reduced. The truſſes are 15 feet apart, and 80 feet $3\frac{1}{2}$ inches ſpan in the clear; the roof is about 200 feet long. Very ample accommodations for the Carpenters and Painters are obtained in the middle ſpace which is 32 feet wide: the ſides are divided into dreſſing rooms, ſtore rooms, &c. the ceilings of which are flat.

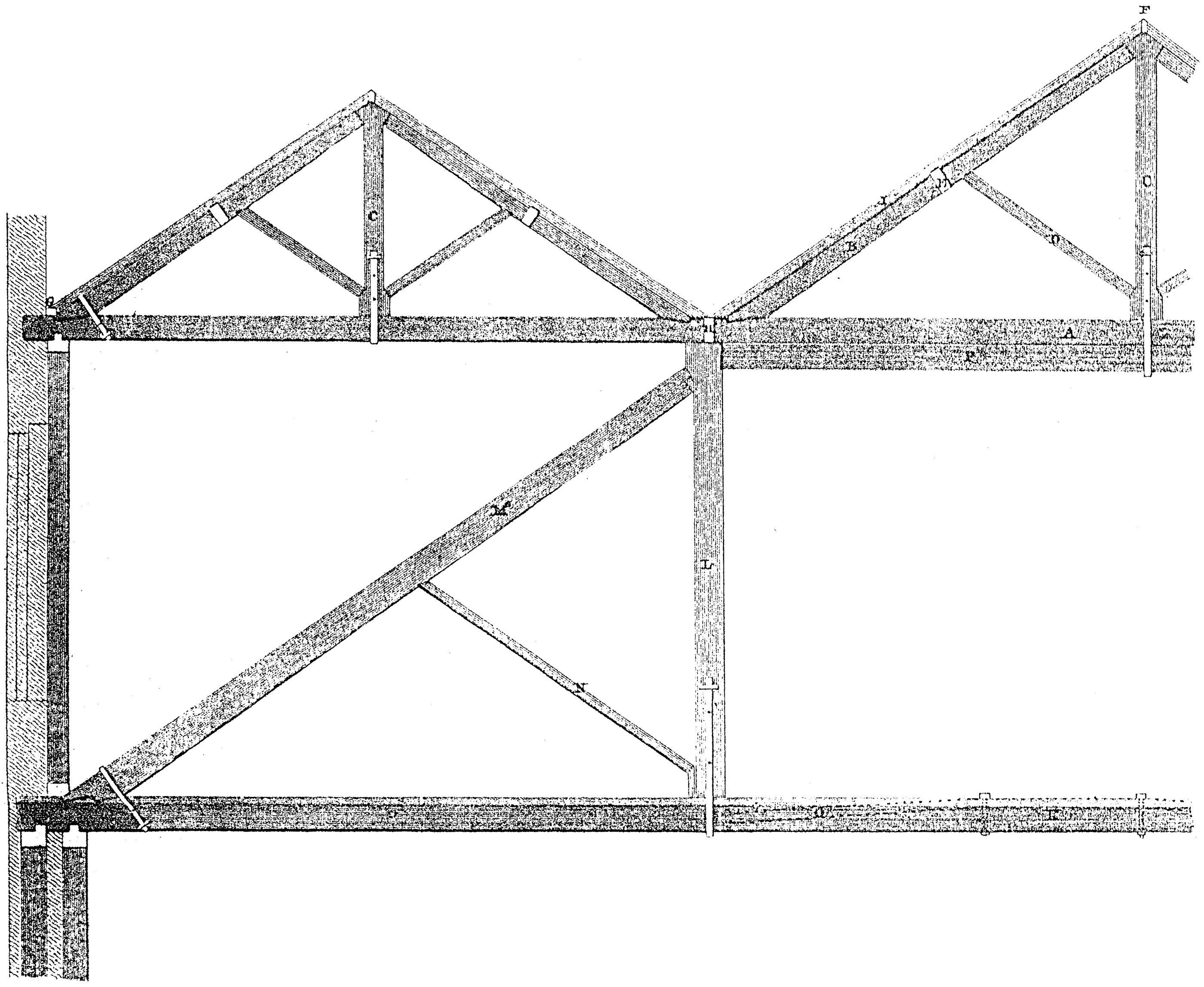
This roof was built in 1793, Mr. Henry Holland, Architect; Mr. Edward Grey Saunders, Carpenter.

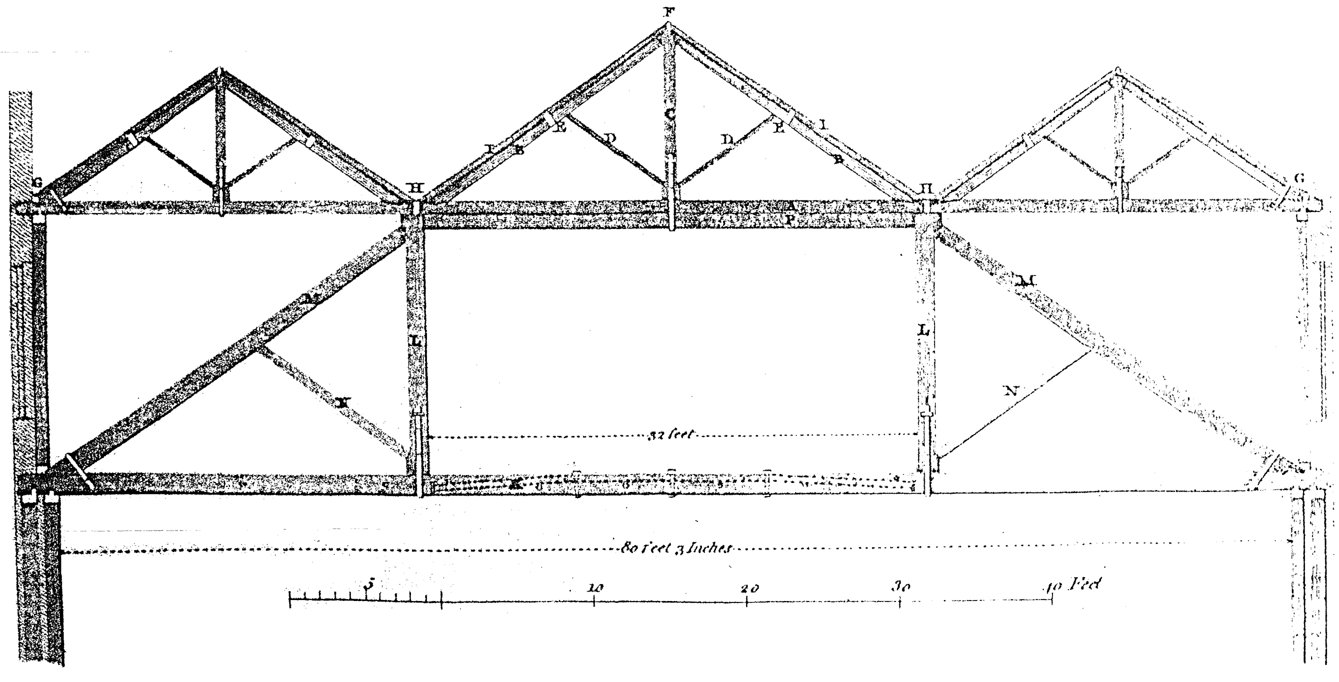
The figures ſhew a truſs entire, and half of a truſs to a larger ſcale.

Scantlings, &c.

A, beams - -	10 in. by 7
B, principal rafters -	7 in. thick
C, king poſts - -	12 in. by 7
D, ſtruts - -	5 in. by 7
E, purlines - - -	9 in. by 5
F, ridges - - -	$1\frac{1}{2}$ in. thick
G, pole plates - -	5 in. by 5
H, gutter plates framed into beams - -	12 in. by 6
I, common rafters -	5 in. by 4 and $2\frac{1}{2}$
K, beams - -	15 in. by 12
L, poſts - - -	15 in. by 12
M, principal braces	14 in. by 12 and 12
N, ſtruts - -	8 in. by 12
O, oak truſſes to the middle bearing of beams -	$5\frac{1}{2}$ in. by $4\frac{1}{2}$
P, ſtraining-beams -	12 in. by 12

PLATE




32 feet
80 Feet 3 Inches
5
10
20
30
40 Feet

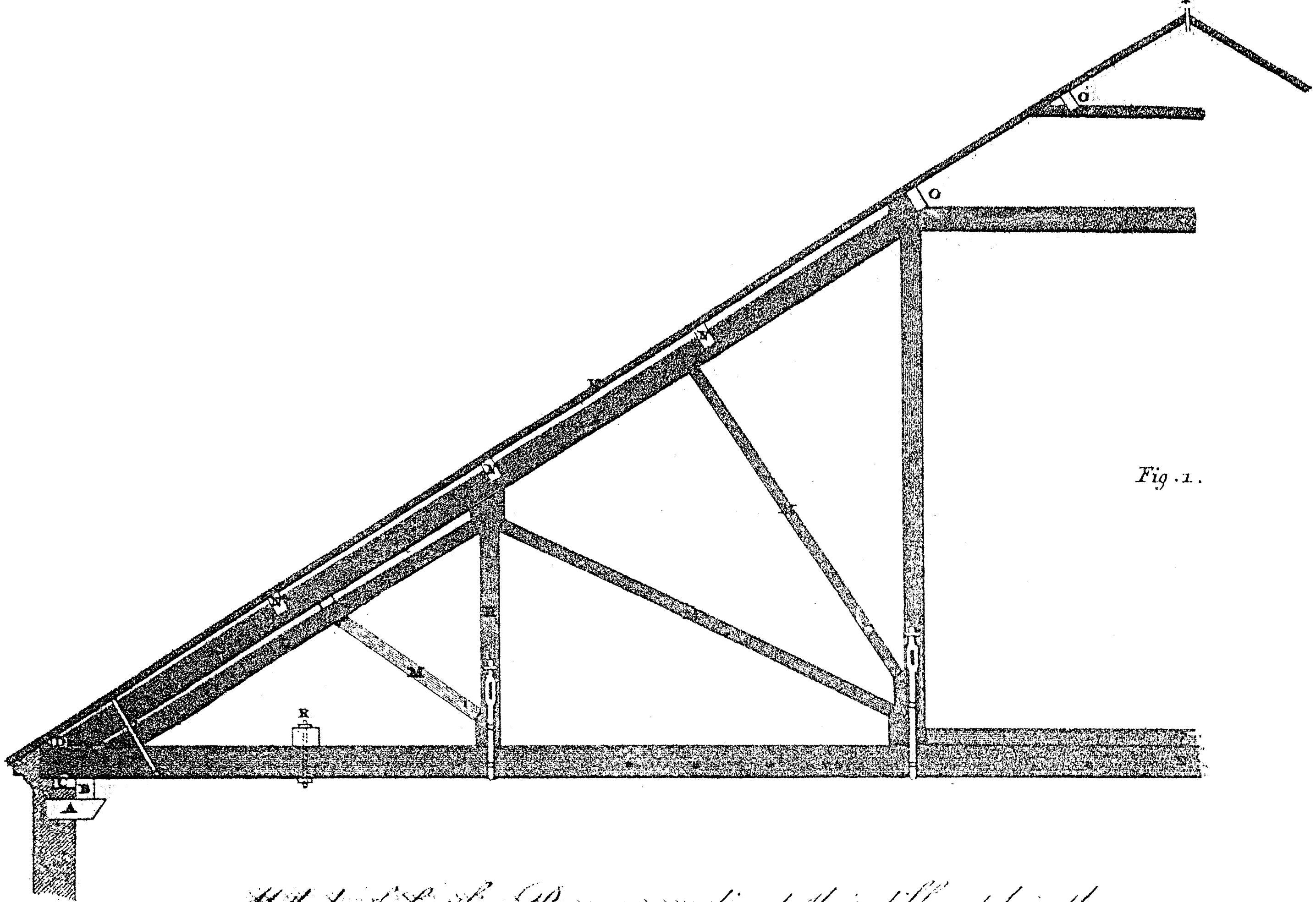


Fig. 1.

Methods of Scarfing Beams, according to their different lengths.

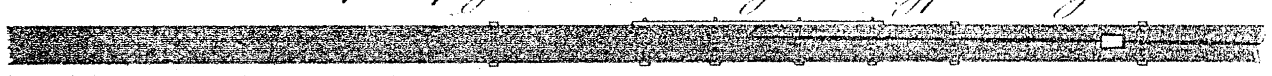


Fig. 2.

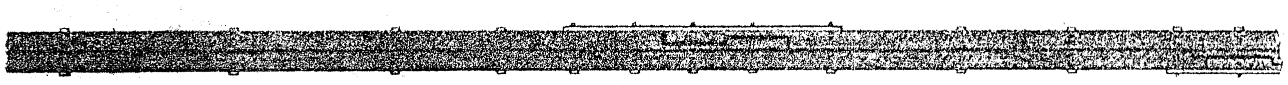


Fig. 3.

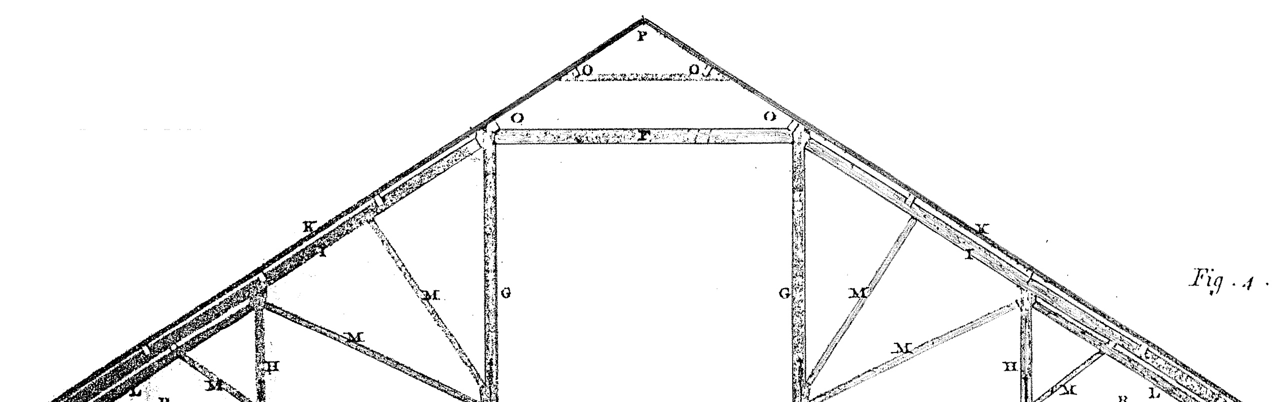


Fig. 4.

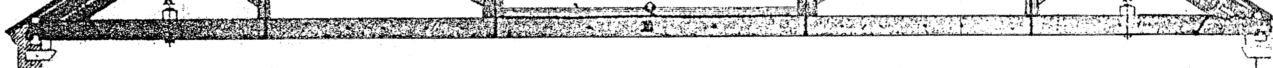


Fig. 5.

Fig. 6.

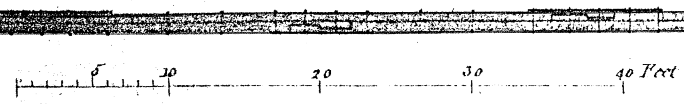


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PLATE LXXIII.

Of the Roof of Birmingham Theatre.

The ſpan of this roof is 80 feet, the conſtruction of the truſs is well adapted to its purpoſes, being ſimple and requiring but little timber conſidering its magnitude. An open ſpace of 19 feet 6 inches wide and 18 feet high, is left in the middle for the various work-rooms, &c. neceſſary for the ſervices of the theatre. The thruſt of the long braces, *M, M*, againſt the foot of the king poſt *G*, is effectually counteracted by the ſtraining ſill *Q*.

There is in this roof an admirable proviſion, which I think ſhould never be omitted in roofs of large extent, to guard againſt the poſſibility of accident from rot or decay at the ends of the beams on the wall; the pieces marked *R*, are placed parallel with the walls at about 7 feet diſtance from the ends of the beams, to each of which it is ſecured by an iron bolt; and for a ſimilar purpoſe the inner plate *B* is an addition to the uſual one *C*; the wall being too thin to admit a plate proportioned in width, to the ſpan of the roof.

The truſſes are about 10 feet apart.

This roof was conſtructed by Mr. George Saunders, Architect, in the year 1794.

FIG. 1, ſhews half the truſs to a larger ſcale.

FIG. 4, ſhews the truſs entire.

Scantlings.

A, oak corbal - -	9 in. by 5	*I I*, principal rafters	12 and 9 in. by 9
B, inner plate - -	9 in. by 9	*K K*, common rafters -	4 in. by $2\frac{1}{2}$
C, wall plate - - -	8 in. by $5\frac{1}{2}$	*L L*, principal braces	9 and 6 in. by 9
D, pole plate - -	7 in. by 5	*M M*, common braces -	6 in. by 9
E, beam - - -	15 in. by 15	*N N*, purlines - -	7 in. by 5
F, ſtraining beam - -	12 in. by 9	*O O*, upper ditto - -	6 in. by 4
G G, king poſt of oak, in the ſhaft	9 in. by 9	*P*, ridge piece - -	9 in. by 2
H H, queen poſt of oak, in the ſhaft	7 in. by 9	*Q*, ſtraining ſill - -	$5\frac{1}{2}$ in. by 9

FIG. 5, 6. Methods of ſcarfing beams.
FIG. 2, 3. The ſame, to a larger ſcale.
The example, *fig.* 6, may be continued to almoſt any length by breaking the joints as ſhewn.

PLATE

PLATE LXXIV.

The manner of framing the Tower or Spire of the Water-works at York Buildings in the Strand, London.

FIG. 1, the elevation of the whole ſpire, naked, conſiſting of fourteen ſtories, ſhowing the manner of framing the timbers.

FIG. 2, the upper part to a larger ſize, ſhowing the dimenſions of the timbers and the manner of framing the top.

FIG. 3, plan of the top, ſhowing how the ribs are framed into the king poſt, and to keep the ribs ſtill more ſecure all the ends are bolted into a circular ring, whoſe centre is the centre of the king poſt.

FIG. 4, a ſection of the tower, ſhowing the braces at the bottom.

FIG. 5, the manner of ſcarfing the angular poſts.

The plan of this building is an octagon, each ſide at the baſe on the outſide of the framing is 9 feet, and each ſide at the top is 2 feet $8\frac{1}{2}$ inches. The ſtories are about 7 feet 10 inches high, from the upper ſide of one floor to the upper ſide of the next.

It may be proper here to obſerve, it would have added much to the ſtrength of this ſpire, if all the timbers had been framed together as in the upper ſtory, ſee *fig.* 2.

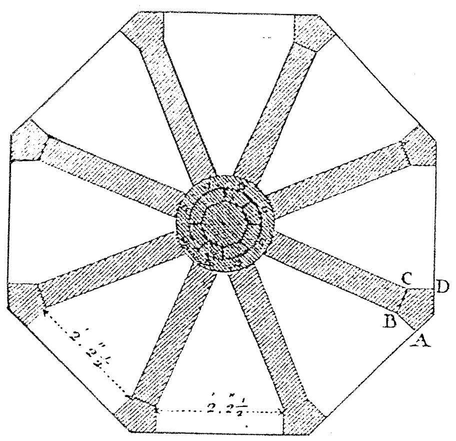
The ſtructure was built by Mr. James King, a Gentleman of conſiderable eminence as a Carpenter, who was engaged in many large works, particularly in the building of Weſtminſter Bridge.

This Tower was built, I have much reaſon to ſuppoſe, previous to the year 1729.

To

Tower of York Buildings Water Works.

Fig. 3.



The sides A.B, B.C *and* C.D *of the angular pieces are each 10 inches at bottom; and* $5\frac{1}{4}$ *at Top.*

Fig. 5.

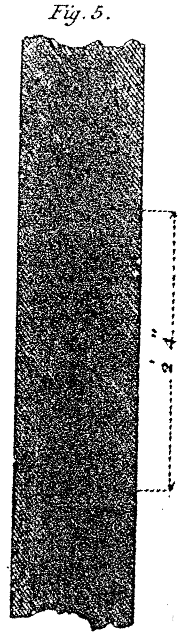
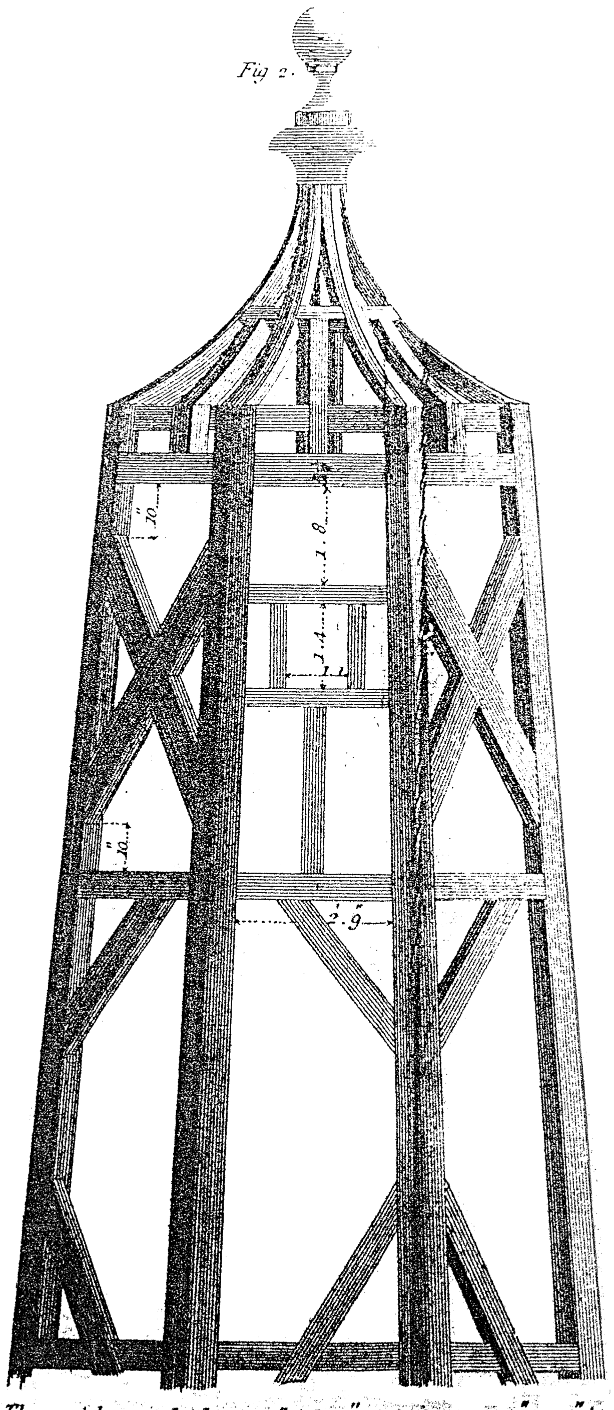


Fig 2.



The upright standards are $9\frac{1}{2}''$ *by* $6''$ *at bottom and* $6''$ *by* $3\frac{1}{4}''$ *at Top.*

Fig 1.

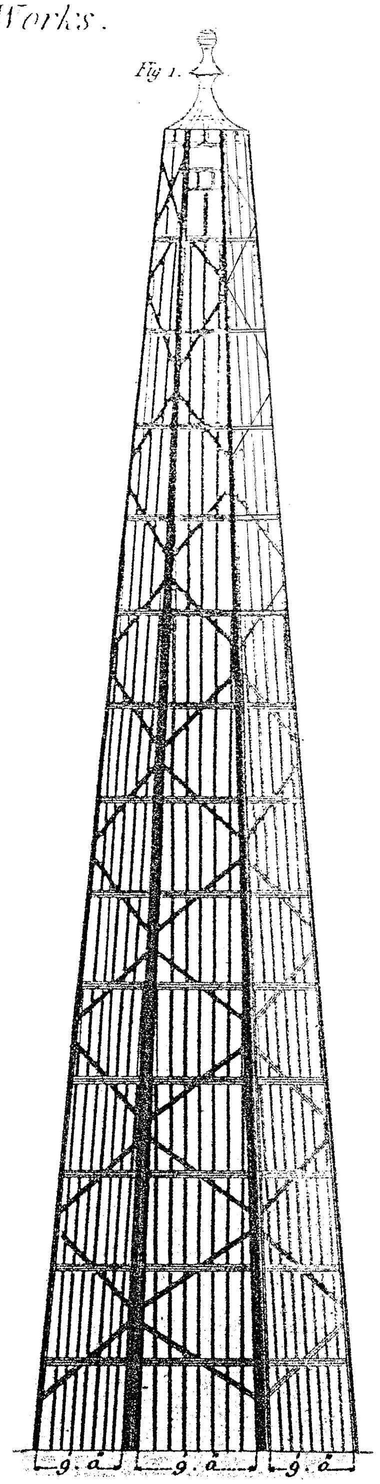
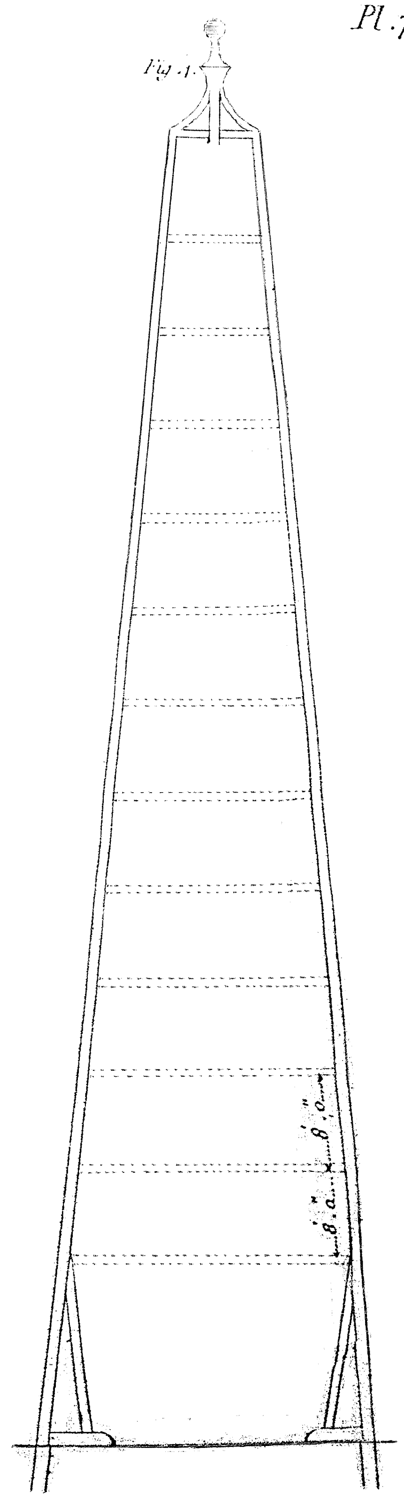


Fig 4.



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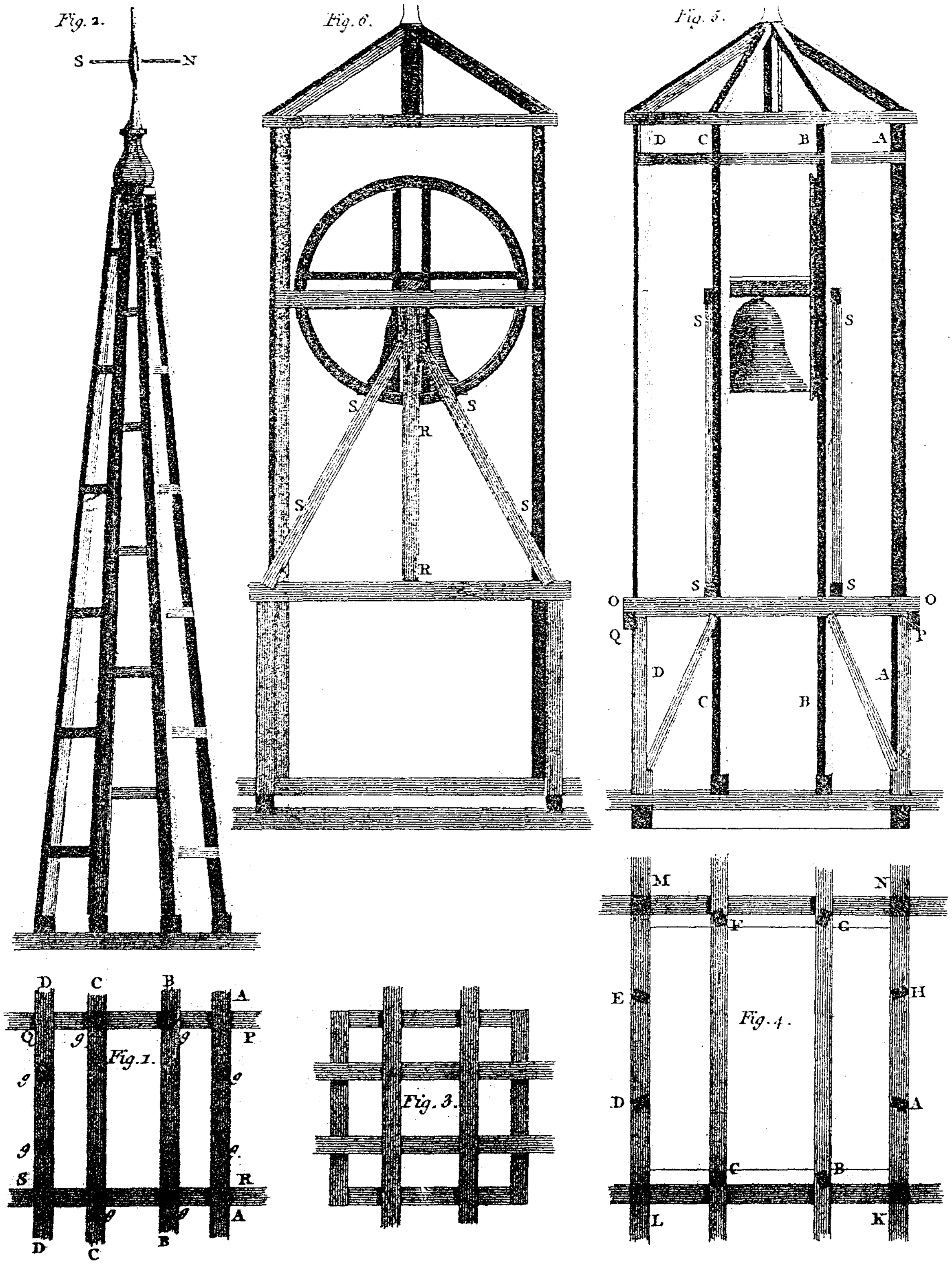

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To increaſe the variety of Towers or Spires, I ſhall now give a Deſign for a Spire, and a Deſign for Turret, with the manner of hanging the Bell.

PLATE LXXV.

Deſign for a Spire, which may be covered with lead, ſhowing the timbers or manner of framing it.

FIG. 1, the plan. *P Q* and *R S*, are ſleepers; *A A*, *B B*, *C C*, *D D*, are beams on which the angle poſts are fixed at *g*, *g*, &c. The ends of theſe beams ſhould be conſiderably longer than ſhewn, which ought to be worked into the wall or timber-work of the baſe, ſo that the action of the wind may be reſiſted by as broad a baſe as poſſible.

FIG. 2, the elevation. The bars are equi-diſtant; thoſe in the ſides are in the middle of the adjoining ones, by which the mortices are at an equal diſtance: thus the angle poſts will be kept as ſtrong as the nature of the thing will admit. The proportion of the ſpire is as 5 to 3.

FIG. 3, another method of framing the floor or plan for a ſpire.

Deſign for a Turret proper for a Chapel, &c. with the truſs for hanging the bell.

The baſe of this turret may be of ſtone, in the form of ſteps, or a pedeſtal, the baſement is therefore framed ſquare to a certain height; the upper part then takes a circular form; the finiſhing, at the upright poſts, may be either pilaſters or columns, ſupporting an entablature, with a domical or other roof.

FIG. 4, plan of baſement or floor, which is ſquare; the ſupports or poſts being placed at *K*, *L*, *M*, *N*. The upper part being circular, the poſts are placed at *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, forming a circle of the diameter propoſed.

FIG. 5, elevation of the turret; *A*, *B*, *C*, *D*, the poſts which form the upper or circular part of the tower, againſt which the pilaſters, &c. are to be fixed. *P* and *Q*, are the poſts which form the baſe or ſquare part of the turret. *O O*, a ſtretcher, under which are the ends of others, which brace or bind the ſquare or pedeſtal part of the turret. *S S*, and *S S*, the braces which ſupport the bell.

FIG. 6. the elevation on the other ſide, ſhowing the truſs to ſupport the bell; *R R* the poſt; *S S*, and *S S* braces. If this turret is finiſhed with a cornice, frize, and architrave, the ſpace between the circular rings at the top may be filled in with blockings, proper o fix them to.

7

Or.

Of Mortices, Tenons, Iron Straps, &c.

The foregoing plates of Roofs having exhibited a variety of the beſt examples, in form, conſtruction, and magnitude, and ſuited to moſt occaſions of importance; to complete the ſubject, I ſhall, in the three following plates, give examples of, and demonſtrate the beſt conſtruction of *Mortices* and *Tenons*, and the beſt poſition for placing *Iron Straps* on the ends of beams, to ſecure them in their places; matters of the greateſt importance to the *Practical Carpenter*, and without a due knowledge of which, the beſt conſtruction may be ſpoiled in the execution.

PLATE LXXVI.

Of Tenons and Mortices, according to their poſition.

Obſerve. If a piece of framing is to ſtand perpendicular, ſuch as partitions, &c. and if there be no preſſure on either ſide, or an equal preſſure be on each ſide of the framing, then it will be beſt to have the mortice and tenon in the middle of the wood, as *A B*. Further

Obſerve, in framing for floors, &c. where the preſſure is entirely on one ſide, the mortices and tenons ought to be neareſt to that ſide on which the preſſure is, becauſe if a piece is cut out on that ſide on which the preſſure is, the timber or beam will be but little weakened, if a piece of hard wood is drove tight into the cavity or notch: in flooring, where the weight of the materials and every additional weight tend to preſs downward, the whole ſtreſs or ſtrain will be upon the upper ſide of the timbers, wherefore the mortice and tenon ought to be as ſhewn at *C, D, E, F*; that at *C, D*, is the moſt ſimple method. *E, F*, is another method by which to obtain more ſtrength in the tenon by an additional ſhoulder or bearing below, which is further aided by the inclined butment or bearing above.

G, the manner of framing together an angular wall-plate for a hip-rafter, with the dragon beam to ſupport the rafter.

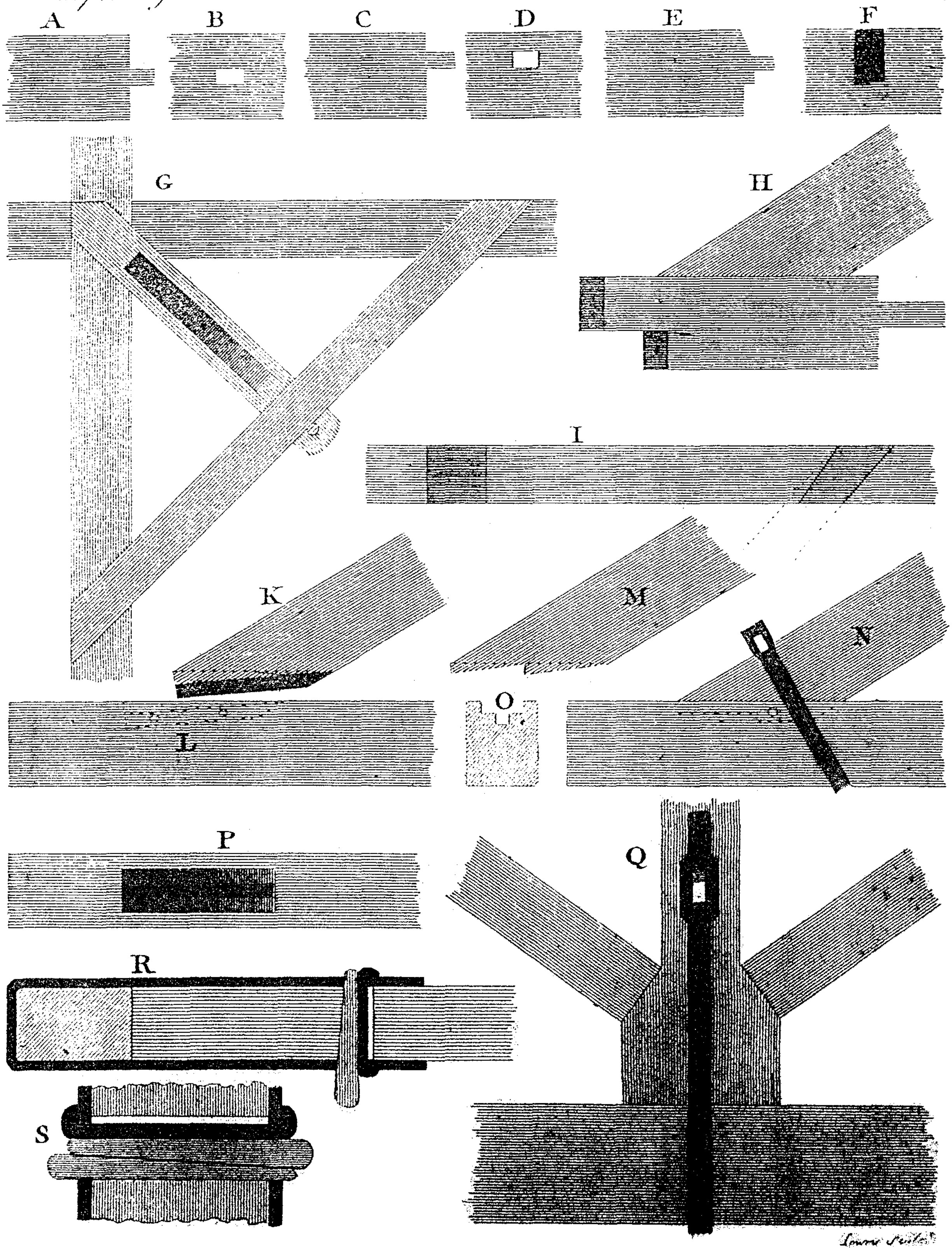
H, the hip rafter, fixed into the dragon-beam, ſhewing its tenon, and the manner in which it is cut, to be fixed on the wall-plate.

I, one of the wall-plates, ſhewing the halving to receive the other plate, and the cutting, for dove-tailing the angular brace.

K, L, the manner of tenoning hip or principal rafters.

M, another method much in uſe for cutting the feet of the principal rafters, in order to give them a double reſiſtance on the tie-beam; but as the beam in this caſe is neceſſarily cut acroſs the grain, in order to receive the rafter, that part of the tie-beam, which is

 left



Lowry sculp.

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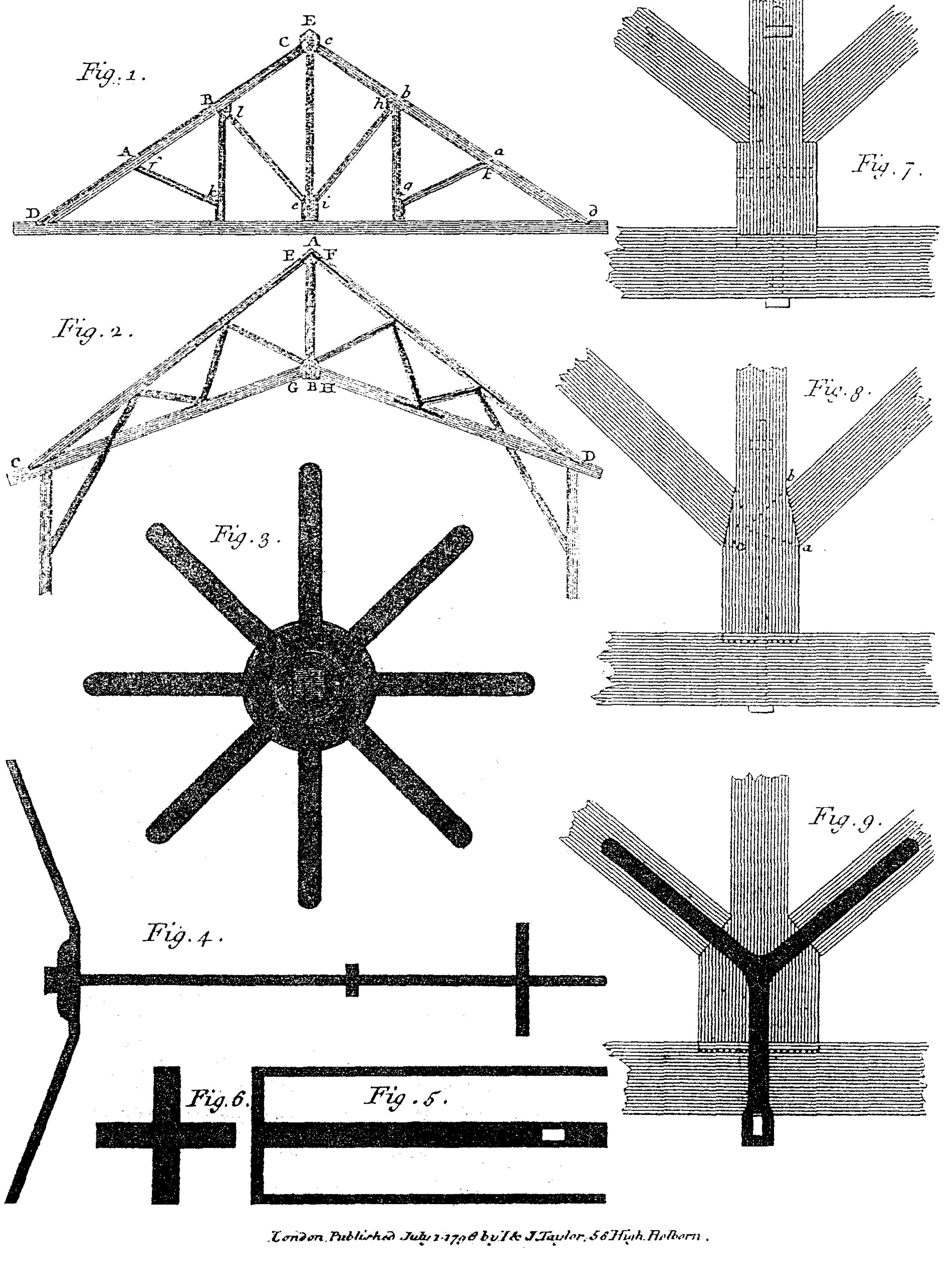
Pl. 77



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left ftanding, to receive the heel of the rafter, is eafily fplit away; a more effectual method, therefore, of obtaining a double refiftance is fhown at *N*, where the focket is cut parallel to the grain of the wood.

O, fection of the tie-beam acrofs the focket, fhewing the mortice of *N*.

P, the upper fide of the tie-beam, fhewing the focket and mortice of the fection *O*.

Q, the manner of ftrapping a king-poft to a tie-beam, fhewing the braces and joggles. The beft form of a butment for a brace, which is joggled into a king-poft, is to have the end of the brace which forces againft the joggle, perpendicular to the fides of the brace; by this means it will have no tendency to flide to one fide or the other, but will keep firmly on its butment.

R, a fection of the king-poft and tie-beam, fhewing the manner of wedging and tightening the ftrap, with a fingle wedge, in order to draw the tie-beam clofe to the king-poft.

S, a fection of the fame part, to a larger fcale, with a double wedge, which will act much eafier than a fingle wedge in driving, as it will have lefs action upon and refiftance from the ends or crofs grain of the wood.

PLATE LXXVII.

OF IRON STRAPS, &c.

In order to eftablifh a rule for the beft method of fixing IRON STRAPS, *it is neceffary to enquire in what manner a trufs is affected by the different preffure of the purlines which fupport the fmall rafters and the coveriug, which alfo will demonftrate the true ufe and fervice of the* KING-POST.

FIG. I. Let the two rafters *C D*, and *c d*, be firmly fixed to the tie-beam *D d*, and the upper ends *C c*, be fixed to the king-poft *E*, the joggles being at right angles with the rafters.—It is evident if a weight acts upon the point *E*, the vertex of the trufs, it will not defcend; for fuppofe the rafters to revolve at the points *D*, *d*, to defcend, the points *C*, *c*, muft come nearer to each other; but this cannot be fo long as the top of the king-poft is incompreffible, and therefore neither the king-poft nor the rafters can defcend. Inftead of a weight acting at *E*, fuppofe a weight hung or fufpended there, acting in the direction of the king-poft *E e*; a weight thus fufpended will endeavour to make the king-poft defcend, the fame as when acting at *E*, now in the endeavour of the king-poft to defcend, it muft force upon the rafters *C D* and *c d*; but as thefe are faft at their butments or points *D*, *d*, the force which acts at the points *C*, *c*, will pufh the rafters in the direction of *C D* and *c d*, confequently the force of the thruft will terminate on the

tie beam, at the points D, d, and will endeavour to extend the beam. Wherefore if this truſs ſhould fail, the rafters muſt burſt, and the tie-beam be broken by tenſion.

Now if this roof has purlines which ſtand upon the points A, B, a, b, a force acting on theſe points will eaſily bend the rafters, wherefore it will be neceſſary to find ſome fixed points in order to keep the points A, B, a, b, from deſcending, or, in other words, to prevent the rafters bending. To this purpoſe fix the ſide-poſts l k and h g, under the purlines B, b, and alſo put in the braces l e, and h i, ſo that the butments at l, e, i, h, may be at right angles to the direction of the braces; then the points B, b, cannot deſcend, for they are ſupported by the points e, i, on the king-poſt, which was ſhown to be immoveable, and therefore the points B and b, will alſo be immoveable: further, the ſhoulders at l and h, will prevent the ſide-poſt l k and h g, deſcending, and conſequently if the braces f k, and g k, are placed under the points A and a, and are firmly fixed to the bottom of the poſts l k, and h g, the points A and a will alſo be ſupported.

As wood is more apt to ſhrink ſideways than in length, ſo the king-poſts and ſide-poſts, in conſequence of the perpendicular poſition of the grain of the wood, and alſo in proportion to the quality of the wood, will be liable to ſhrink, the rafters of conſequence will deſcend; this muſt be guarded againſt by the application of iron ſtraps in proper poſitions, as will be afterwards ſhown.

To obviate all the objections of the ſhrinking of the king-poſt, we have inſtances of their being being made of iron, as in the roof to Greenwich Hoſpital, Plate 71; and this might be uſed with propriety in the circumſtances of the rafters butting againſt each other, as in *fig.* C, Pl. 78. See alſo this further applied in *fig.* 1, Pl. 79.

On the ſhrinking of the king-poſt, it ſhould be obſerved, that in a roof of 50 feet ſpan, where the rafters are 30 feet long, a ſhrinking of half an inch at the king-poſt will occaſion the whole of the roof to deſcend nearly one inch; and if the pitch is leſs than a third, the effect will be increaſed.

Fig. 2. Section of a truſs for a *circular building*. A B, the king-poſt, which muſt have as many ſides as there are truſſes in the roof, G C and H D are tie-beams, affixed to the king-poſt, E C and F D, are the principal rafters: now it is evident from the mere weight of the materials, that the timbers of this roof will deſcend or fall down, if ſome method is not taken to prevent it;—for ſuppoſe the joints C, D, E, F, G, H, to be looſe, then the heads of the rafters will preſs againſt the king-poſt at A, and the bottom of the rafters forcing againſt the tie-beams at C, D, will ſeparate them from the bottom of the king-poſt B; but if the tie-beams are firmly fixed to the king-poſt, then this roof will be ſecure. Now the method I propoſe for effecting this, is, to tie all the beams to the king-poſt as a common centre by means of an iron ſtrap, in the form of *fig.* 3, conſiſting of as many branches as there are tie-beams to be united; this figure alſo ſhows the plan of the roof. Now the centre of this ſtrap being made ſecure to the king-poſt, and an arm being bolted to each of the tie-beams, will I think render the whole ſecure and permanent. *Fig.* 4, is a ſection of the ſtrap, ſhewing the bolts and croſs nuts which are to be let into the king-poſt, to faſten the plate up to the bottom of the king-poſt. *Fig.* 5, is

is another method of faſtening the plate to the king-poſt, by ſtraps or braces, croſſing the centre of the ſtrap at right angles, and which is to be teightened by wedges. *Fig.* 6, is a plan of the ſame.

FIG. 7. The manner of joggeling a pair of braces into the bottom of a king-poſt, when its thickneſs will not admit of ſquare joggles. This figure alſo ſhews the method of uniting or ſuſpending the tie-beam to the king-poſt, by an iron bolt and nuts, as expreſſed by the dotted lines.

FIG. 8. Is another method of joggeling the braces with bevel joints, when the bottom of the king-poſt is narrow; but by this method the braces are liable to ſlide away from the joggle, if there be not a tenon ſufficiently ſtrong to prevent it. Some carpenters make the tenon in the form of an iſcoſceles triangle, as *a b c*, of which the ſide *a c*, is equal to *a b*; but this method cuts and weakens the king-poſt too much: the beſt kind of tenon under theſe circumſtances, is as ſhown on the other ſide by the dotted lines.

FIG. 9. A method of ſtrapping a pair of braces to a king-poſt, and ſuſpending the tie-beam: that part of the king-poſt on which the braces reſt being liable to ſhrink, the braces of conſequence muſt follow, by which the principal rafters looſing their ſupport, will bend; now if a ſtrap is fixed, as ſhewn by this figure, the braces will be kept ſecure in their poſition, and the rafters of conſequence will not bend.

PLATE LXXVIII.

OF IRON STRAPS.

FIG. *A.* The upper part of a king-poſt and principal rafters, ſtrapped together. The ſtrap is here fixed in the direction of the rafters, and if well bolted to the rafters it will prevent them coming nearer together at the top in caſe the king-poſt does ſhrink; conſequently the rafters will not fall in: wherefore the roof will always be maintained in the exact poſition as firſt executed.

FIG. *B.* Straps are frequently fixed in this manner: that is, perpendicular to the edge of the rafter; but this will not prevent the upper ends of the rafters coming nearer to each other, for the braces which are ſuppoſed to act againſt the bottom of the king-poſt, or the ſwag of the tie-beam, will force down the king-poſt, and the form of this ſtrap will not prevent the ends of the rafters cloſing to the head of the king-poſt, in caſe it has ſhrunk: but if a purline, or any particular weight be over the ſtrap, then the poſition for reſiſting that weight will be good; but in the conſtruction of a roof purlines are ſeldom or never placed at the head of a rafter; the only force which acts in the direction

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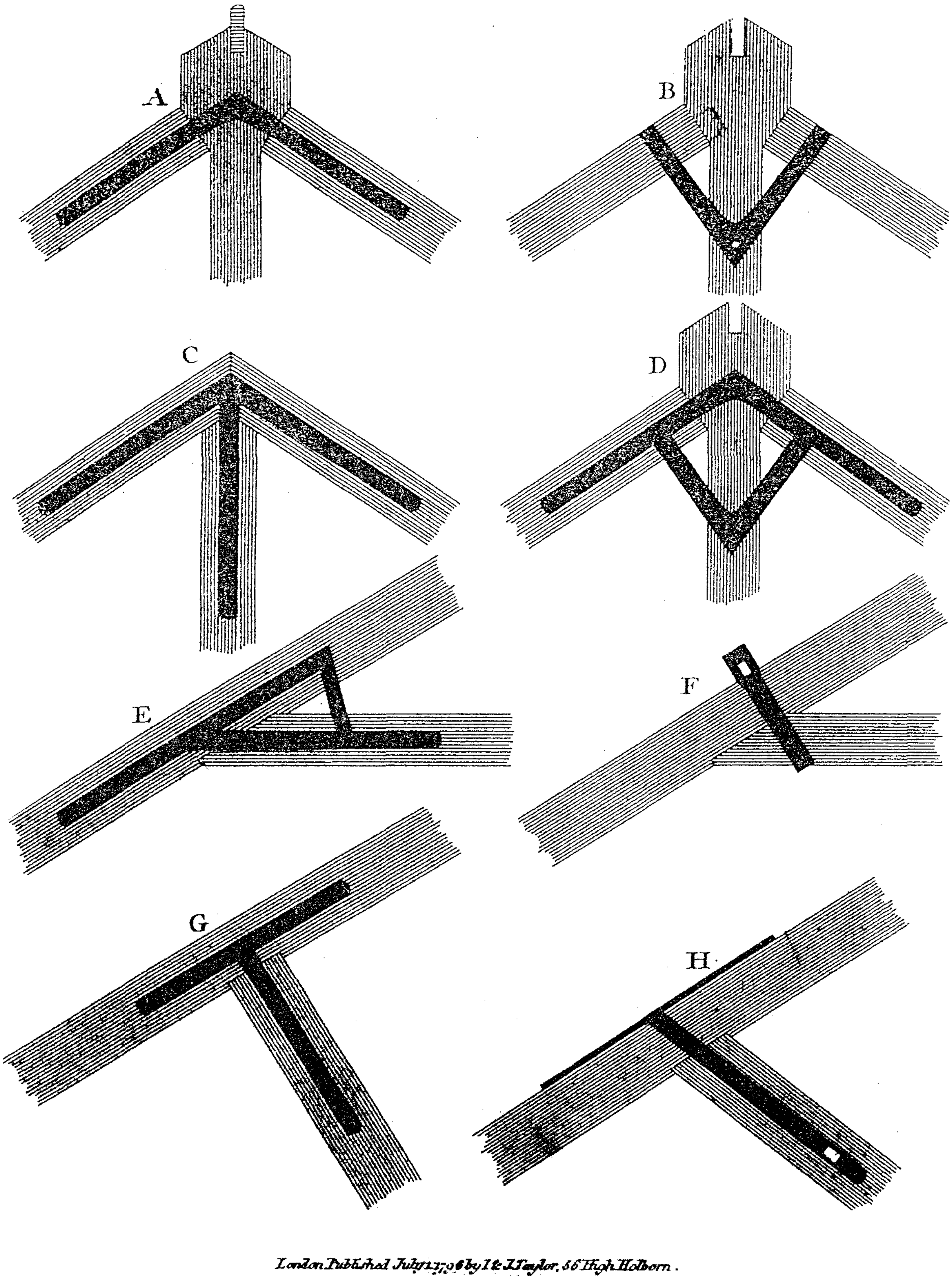

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of this ſtrap, is the weight of this portion of the rafter, which is inconſiderable when compared with the quantity of force which acts in the direction of the rafters.

FIG. *C.* Another method of ſtrapping the principal rafters to a king-poſt. When the ends of the rafters meet, as in the conſtruction ſhown by this figure, the roof will be but little liable to ſwag or fall in, in the middle; as there is no ſubſtance between the rafters, there can be no ſhrinking.

FIG. *D.* Shows the method of ſtrapping the principals to a king-poſt, in circumſtances where the rafters are liable to two preſſures, viz. one, in the direction of their length, and the other perpendicular to that direction.

FIG. *E.* The manner of ſtrapping a collar-beam to a principal rafter. If a roof has a collar-beam and a king-poſt; and, if the ſtrap which unites the principals to the king-poſt be placed in the middle of the principal rafter, as *fig. A*, ſo ought the ſtrap which fixes the collar-beam to the rafter to be placed in the middle of the principal rafter.

FIG. *F.* Is in another method for the ſame purpoſe: but ſuppoſing the feet of the rafters to be extended by the weight of the roof, which will endeavour to extend the collar-beam, then this ſtrap will turn round upon the back of the rafter, and conſequently the rafter will be ſeparated from the collar-beam;—now the conſtruction of the ſtrap, *fig. E*, is perfectly ſecure from ſuch a ſtrain.

FIG. *G.* A ſtrap proper for fixing a brace to a principal rafter. When the ſtrap which unites the king-poſt to the principal rafters is fixed in the middle of the rafters, as at *A*, then this is the beſt poſition, becauſe when all the ſtraps are fixed alike, they keep the edges of the rafters in ſtraight lines.

FIG. *H.* The method of ſtrapping a brace to a principal rafter: when the ſtrap which unites the king-poſt to the rafters goes over the upper edges of the rafters, as is ſhown in *fig.* 3, Pl. 79.

PLATE LXXIX.

OF IRON KING-POSTS.

FIG. 1. Is a deſign for a truſs with king-poſts and queen-poſts of iron, with ſtraps going over the rafters; the feet of theſe poſts are made in form of a ſaddle; and therefore the braces will have a firm butment againſt the iron, and will not be ſubject to be looſe or ſlack by the ſhrinking of the tie-beam. The tie-beam is hung up by bolts through the bottoms of the ſaddles at *B A* and *C*; *B C* is a ſtraining-piece, the ends of which lie in the ſaddles *B C*, and butt againſt the braces *D E* and *F G*, thereby keeping the butments at *D* and *F* ſecure.

FIG. 2.

Strength of Timber, &c.

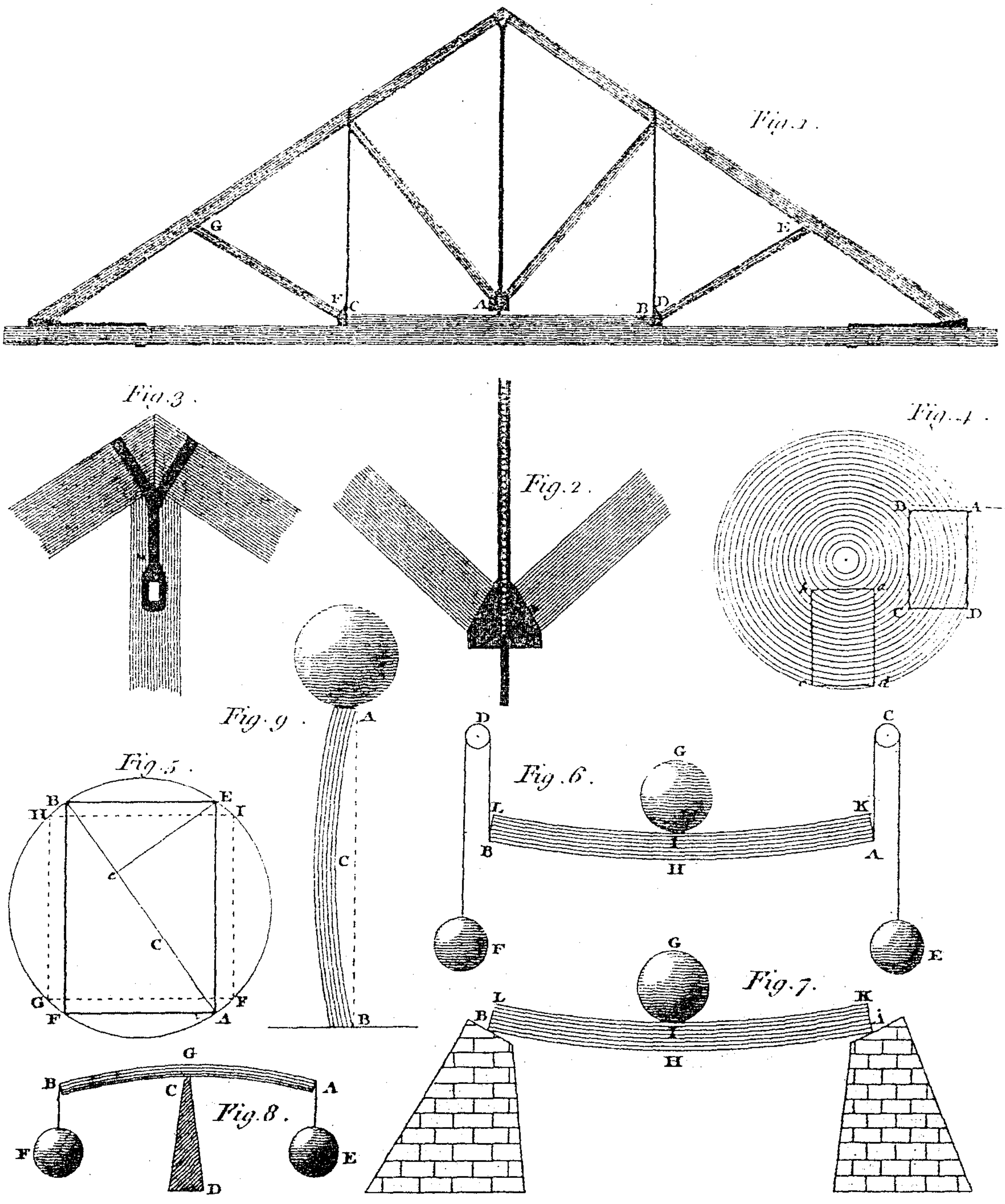

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FIG. 2. The faddle at *A*, to a larger fcale, fhewing the butment of the braces by dotted lines, either with a triangular butment, as *A B C*, fo that it may have a fquare butment, or the braces may meet each other in the line *A D*.

FIG. 3. Shews another method in addition to thefe already defcribed, by which to hang up a king-poft to the rafters, the ends of the rafters being in contact: The upper end of the ftrap is made in two branches going over the rafters at right angles to each other. The bottom of the ftrap is made wider, that it may be bolted in two places in the breadth, by this means to have a greater refiftance.

ON THE STRENGTH OF TIMBER.

IN my former publication, I have given fome inveftigations and rules for calculating the proportional ftrength of timber, founded upon the theory of the celebrated Galileo, which differs but little from the truth as will be hereafter fhown: the theory fuppofes the timber to have no degree of elafticity, and the texture perfectly uniform, in which cafe it will be neither compreffed nor extended, and when it breaks, all the particles will be feparated at once. The rule upon this fuppofition for finding the relation of the ftrength of different pieces of the fame texture, will be accurately the proportion of the numbers arifing by multiplying the fquare of the depth of each piece by its breadth, and divided by its length: confequently the harder, non elaftic or more brittle, a piece of timber is, the nearer will it correfpond to this rule. Wherefore it appears that the rule which will apply for finding the relative ftrengths of one fpecies of timber, will not fuit for other kinds whofe textures are of a different nature.

From the preceding confiderations, therefore, it appears we muft not hope to find a rule which fhall apply to fcantlings of all timbers generally; and the only means on which we muft place any hope of difcovering a rule for afcertaining the relative ftrengths of different kinds of timber, is from the refult of a great number of experiments made on each fpecies with all poffible care and accuracy, and upon a large fcale. But the labour and expence attending fuch experiments on a fcale likely to be at all ufeful, far exceed the abilities of individuals who might otherwife be difpofed to inveftigate this ufeful branch of mechanical knowledge. This grand objection no doubt has been the caufe why fo little has been done to determine this fubject by experiments: yet as we are not abfolutely without fome lights, we fhall proceed to lay the fame before our readers in as concife a manner as the clearly explaining the matter will admit.

The firft authority to our purpofe is what *Belidor* has given on this fubject in his *Science des Ingenieurs*.

BELI-

BELIDOR'S EXPERIMENTS.

The column *B*, contains the breadths of the pieces in inches; the column *D*, contains their depths; the column *L* contains their lengths; *P* the weight (in pounds) which broke them, when hung on their middles.

In order to obtain the beſt idea of the ſtrengths of pieces of different dimenſions, with more certainty, three pieces of each dimenſion were tried, a medium among them being more accurate than a ſingle experiment.

The column M contains the mediums.

The experiments were made on oak, of equal quality, and tolerably well ſeaſoned.

	B	D	L	P	M
Experiments 1ſt, ends looſe	1	1	18	400 415 405	406
Experiments 2d, ends firmly fixed	1	1	18	600 600 624	608
Experiments 3d, ends looſe	2	1	18	810 795 812	805
Experiments 4th, ends looſe	1	2	18	1570 1580 1590	1580
Experiments 5th, ends looſe	1	1	36	185 195 180	187
Experiments 6th, ends fixed	1	1	36	285 280 285	283
Experiments 7th, ends looſe	2	2	36	1550 1620 1585	1585
Experiments 8th, ends looſe.	$1\frac{2}{3}$	$2\frac{1}{3}$	36	1665 1675 1640	1660

By comparing experiment the 1ſt, with experiment 3d, the ſtrength appears proportional to the breadth, the length and depth of each piece being the ſame.

By comparing experiments the 1ſt and 4th together, the ſtrength appears as the ſquare of the depth nearly, the breadth and length being all the ſame.

By comparing experiment the 1ſt and 5th together, ſhows the ſtrength to be nearly as the lengths, inverſely, the breadth and depth of each piece being the ſame.

By comparing experiments 5th and 7th together, ſhows the ſtrengths, nearly in proportion to the breadth, multiplied by the ſquare of the depth, the length being the ſame in both.

By comparing experiments 1ſt and 7th together, ſhows the ſtrengths to be as the ſquare of the depth, multiplied by the breadth, and divided by the length. Experiments 1ſt and 2d, ſhow the increaſe of the ſtrength by faſtening the ends, to be, in the proportion of 2 to 3. Experiments the 5th and 6th, ſhow the ſame thing.

By

By the above experiments it appears that the rule founded upon the Galileon hypothesis for finding the comparative strength of timber, is nearly true. But as it would be wrong to draw conclusions from timbers of so small scantling, as in the above experiments, we shall, after making the following observation, give an abstract of the experiments of *M. Buffon* and those of *M. du Hamel*, men of acknowledged abilities, who were directed by the government of France to make experiments on this subject; and who were supplied with ample funds and apparatus for the purpose, and had the choice of the best subjects in all the forests of France. The reports of M. Buffon may be found in the memoirs of the French Academy, for the years 1740, 1741, 1742, 1768, and those of M. du Hamel, in his work, *Sur l'Exploitation des Arbres, et sur la Conservation et le Transportation de Bois.*

But we observe, the chief cause of the irregularity in such experiments, is the fibrous, or rather plated texture of timber, which consists of annual additions, whose cohesion with each other is vastly weaker, than that of their own fibres. Let *fig.* 4, Pl. 79, represent the section of a tree, and *A B C D*, and *a b c d*, the section of two battens, to be cut out of it, for experiment; let *A D*, and *a d*, be the depths; and *D C*, *d c*, the breadths; the batten *A B C d*, will be the strongest; for the same reason that an assemblage of planks, set edge ways, will be stronger than the same number of planks laid above each other.

M. Buffon found that the strength of *A B C D*, was to that of *a b c d*, in oak, nearly as 8 is to 7.

The authors of the different experiments, we have reason to fear, were not very careful that their bars had their plates all disposed the same way.

As great beams occupy much, if not the whole, section of the tree, and from this it has happened that their strength is less than in proportion to that of a small lath or batten; for which reason a set of experiments ought to be carefully made on each, as all large buildings require a great number of both kinds: as girders and other beams for supporting large weights, so small bars or battens are employed in making joists, rafters, purlines, &c., all of which are for the purpose of carrying or discharging weights.

M. de Buffon's Experiments.

The following table exhibits a number of experiments on bars of sound oak, clear of knots, each bar being four inches square.

The column No. 1, contains the length of the bar, in feet, between the two props.

The column, No. 2, contains the weight of the bar, the second day after it was felled, in pounds.

The column, No. 3, contains the number of pounds necessary for breaking the bar in a few minutes.

The column, No. 4, contains the number of inches it bent down before breaking.

The column, No. 5, contains the number of minutes that each respective piece was in breaking.

In

In this table two bars were tried of each length, each of the firft three pairs confifted of two cuts of the fame tree; the one found next to the root, was always found to be the heavieft, ftiffeft and ftrongeft; from which M. Buffon recommends a certain and fure rule for eftimating the goodnefs of timber by its weight; he finds that this is always the cafe when the timber has grown vigorouſly, forming thick annual layers. But he alfo obferves that this is only during the advances of the tree to maturity, for the ftrength of the different circles approach gradually to an equality during the healthy growth of the tree.

1	2	3	4	5
7	60 56	5350 5275	3.5 4.5	29 22
8	68 63	4600 4500	3.75 4.7	15 13
9	77 71	4100 3950	4.85 5.5	14 12
10	84 82	3625 3600	5.83 6.5	15 15
12	100 98	3050 2925	7 8	

Experiments on other fizes were made in the fame manner: a pair, at leaft, of each length and fcantling was taken; the mean refults is contained in the following table. The beams were all fquare, and their fizes in inches are placed at the head of the columns, and their length, in feet, in the firft column. The column *A* exhibits the ftrength which each of the five inch bars ought to have by the theory.

M. Buffon, found by numerous experiments, that oak timber loft much of its ftrength by drying or feafoning, and therefore in order to fecure uniformity, his trees were all felled in the fame feafon of the year, were fquared the day after, and tried on the third day. Trying them in this green ftate, gave him an opportunity of obferving a very curious phenomenon.

When the weights were laid brifkly on, nearly fufficient to break the log, a fmoke was obferved to iffue from each end, accompanied with a hiffing noife, which continued while the tree was bending and cracking; owing to the ftrain which muft arife by the bending of the log, in which ftate it muft be both compreffed and extended.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14		5300	7475	13225	19775	5763
16		4350	6362	11000	16375	5042
18		3700	5562	9245	13200	4482
20		3225	4950	8375	11487	4034
22		2975				3667
24		2162				3362
28		1775				2881

From

From the above experiments some conclusions respecting the law of the strength of oak timber may be deduced, from which it will be seen whether the theory already established is sufficiently accurate, or if not, they will show in what manner it ought to be corrected.

M. Buffon considers the experiments upon the five-inch bars, as the standard of comparison, having both extended these to a greater length, and having tried more pieces of each length.

The theory determines the relative strengths of bars of the same section, to be inversely as their lengths; but if the five experiments in the first column, be excepted, there will be found a very great deviation from this rule: thus the five-inch bar of 28 feet long, should have half the strength of that of 14 feet or 2650; whereas it is but 1775; the bar of 14 feet should have half the strength of the seven feet, or 5762, whereas it is but 5300; and in like manner the fourth of 11,525 is 2881; but the real strength of the 28-inch bar, is but 1775. The column *A*, exhibits the strength that each of the five-inch bars ought to have, by the theory, which decreases much slower than those shown by the experiment; and therefore it appears, that the strength of different pieces of timber decrease much quicker than that of the inverse ratio of their lengths; but in what ratio precisely, the strength decreases, would be almost impossible to know, as there is not a sufficient number of experiments for the purpose; the few that have been tried are so very anomalous, as will appear by taking the differences between those in the third column, found by the experiments, from their respective numbers under *A*, in the seventh column, as found by the rule, which are respectively, 298, 656, 943, 648, 463, 692, 782, 809, 692, 1200, 1106; by comparing these numbers together, it is easy to see the impossibility of discovering any progression, or regular increase; for example, the third difference is greater than any of the preceding, and less than any of the proceeding, excepting the two last, and therefore it appears, that no rule can be founded on these experiments, for finding the relative strength of timber, but what will in many cases differ very considerably from that which ought to correspond to it; in the table however, the rule given in my former calculations may, if somewhat corrected, correspond nearly with the five-inch bars, as follows: from the length of the required piece, take the seven feet length, and multiply the difference by the number 1474, and divide that product by the length, and substract the quotient from the number of pounds found by the former rule, and the remainder will be the answer.

M. Buffon uniformly found that ⅔ds of the weight which was sufficient to break a beam at first, sensibly impaired its strength, and frequently broke it, at the end of two or three months, and one half of this weight brought it to a certain curvature, which did not increase after the first minute or two, and may be borne by the beam for any length of time.

One-third seemed to have no permanent effect on the beam; but it recovered its rectilineal shape completely, even after it had been loaded several months, provided that the timber was seasoned when first loaded; that is to say, one-third of the weight which would quickly break a seasoned beam, or one-fourth of what would break one just felled, may lie on it for ever, without giving the beam a set.

The agreement of the numbers, found by the rule of the breadth, being multiplied by the square of the depth, appears to deviate less from the experiments of Buffon, than that

of

of the inverſe ratio of the length; but even this rule applied to ſofter woods, will differ greatly from the truth, which muſt be evident when we conſider a beam juſt breaking, that it will be ſtrongly compreſſed on the ſide neareſt to the axis of fracture, and the oppoſite ſide will be greatly extended, conſequently there muſt be ſome point between the fulcrum and the oppoſite ſide, which will neither be extended nor compreſſed, and all the fibres lying between this point and the fulcrum, being in a ſtate of compreſſion, and therefore have little reſiſtance in preventing the fracture, thoſe fibres on the other ſide only are exerted.

This is fully verified by ſome curious

Experiments made by M. Du Hamel.

He took 16 bars of willow, two feet long and half an inch ſquare, and ſupported them by props under the ends, he broke them with weights hung on their middle. He broke four of them by weights of 40, 41, 47 and 52 pounds, the mean is 45.

He then cut four of them $\frac{1}{3}$d through, on the upper ſide, and filled up the cut with a thin piece of harder wood, ſtuck in very tight; theſe were broken 48, 54, 50 and 52, the mean of which is 51.

He cut other four half through; they were broken by 47, 49, 50 and 46, the mean of which is 48.

The remaining four were cut $\frac{2}{3}$ds, and their mean ſtrength was 42.

Another ſet of experiments ſtill more remarkable.

Six battens of willow, 36 inches long, and $1\frac{1}{2}$ ſquare, were broken by 525 pounds, at a medium.

Six bars were cut $\frac{1}{3}$d through, and the cut filled with a wedge of hard wood, ſtuck in with little force; thoſe broke with 551 pounds.

Six bars were cut $\frac{1}{2}$ through, and the cut was filled up in the ſame manner; they broke with 542.

Six bars were cut $\frac{3}{4}$ths through, and loaded till nearly broken; were unloaded and the wedge taken out of the cut; a thicker wedge was put in tight, ſo as to make the batten ſtraight again, by filling up the ſpace left by the compreſſion of the wood; this batten broke with 577 pounds.

Of the absolute Strength of Timber.

The ſtrain which ariſes by pulling timber in the direction of its length, is called Tenſion, this ſtrain frequently occurs in roofs, and is therefore worthy conſideration.

The abſolute ſtrength of a fibre, or ſmall thread of timber, is the force by which every part of the fibre is held together, which is equal to the force that would be required to pull it aſunder, and the force which would be required to tear any number of threads aſunder, is proportional to all of them; but the areas of the ſections of two pieces of timber compoſed of fibres of the ſame kinds, are as the number of fibres in each; and therefore the ſtrength of the timber, is as the area of the ſections.

Hence all priſmatic bodies are equally ſtrong; that is, they will not break in one part more than another.

Bodies

Bodies which have unequal ſections, will break at their ſmalleſt part, and therefore if the abſolute ſtrength which would be required to tear a ſquare inch, of each kind of timber be known, we ſhall be able to determine the ſtrength of any other quantity whatever.

The following table is taken from Muſchenbroëk's experiments, he has deſcribed his method of trial minutely; the woods were all formed into ſlips fit for his apparatus, and part of the ſlip was cut away to a parallelopiped $\frac{1}{5}$ of an inch ſquare, and therefore the 25th part of a ſquare inch in ſection; the abſolute ſtrengths of a ſquare inch were as follows:

	lb.		lb.
Locuſt tree, -	20,100	Pomegranate, -	9,750
Jujeb, - -	18,500	Lemon, - -	9,250
Beech Oak, -	17,300	Tamarind, -	8,750
Orange, -	15,500	Fir - -	8,330
Alder, -	13,900	Walnut, -	8,130
Elm, - -	13,200	Pitch Pine -	7,650
Mulberry, -	12,500	Quince, -	6,750
Willow, - -	12,500	Cypreſs, -	6,000
Aſh, - -	12,000	Poplar, - -	5,500
Plum, - -	11,800	Cedar, -	4,880
Elder, -	10,000		

M. *Muſchenbroëk*, has given a very minute detail of the experiments on the aſh and walnut, ſtating the weight which will be required to tear aſunder ſlips taken from the four ſides of the tree, and on each ſide in a regular progreſſion, from the center to the circumference. The numbers of this table, correſponding to the two timbers, may therefore be conſidered as the average of more than fifty trials made on each, and he ſays that all the others were made by the ſame care, and therefore there is no reaſon for not confiding in the reſults.

Practical Observations.

The following obſervations on Woods, will be of great uſe to the practical carpenter in making a proper choice of timber, according to the purpoſes he may want to employ it for.

1ſt. The wood immediately ſurrounding the pith or heart, is the weakeſt, and its inferiority is ſo much more remarkable as the tree is older. *Muſchenbroëk's* detail of experiments is decidedly in the affirmative. *M. Buffon*, on the other hand, ſays that his experience has taught him that the heart of a ſound tree is the ſtrongeſt, but he gives no inſtances; it is certain, from other experiments, on large oaks and firs, that the heart is much weaker than the exterior parts.

2d. The wood next to the bark, commonly called white or blea, is alſo weaker than the reſt, and the wood gradually increaſes in ſtrength as we recede from the centre to the blea.

3d. The wood is ſtronger in the middle of the trunk, than at the ſpringing of the branches, or at the root, and the wood of the branches is weaker than that of the trunk.

4th. The wood on the north ſide of all trees, which grow in the European climates, is

 the

the weakeſt, and that of the ſouth ſide is the ſtrongeſt; and the difference is moſt remarkable in hedge-row trees, and ſuch as grow ſingly.

The heart of a tree is never in its center, but always nearer to the north ſide, and the annual coats of wood are thinner on that ſide. In conformity to this it is a general opinion of carpenters, that timber is ſtronger whoſe annual plates are thicker. The trachea, or air veſſels, are weaker than the ſimple ligneous fibres. Theſe air veſſels are the ſame in diameter and number of rows, in trees of the ſame ſpecies, and they make the viſible ſeparation between the annual plates. Therefore when theſe are thicker, they contain a greater proportion of the ſimple ligneous fibres.

5th. All woods are more tenacious while green, and loſe very conſiderably by drying after the tree is felled. I ſhall here conclude theſe obſervations with the following uſeful problem.

To cut the ſtrongeſt Beam poſſible, out of a round Tree, whoſe Section is a given Circle.

FIG. 4. Pl. 79. Let *A E B F*, be the ſection, draw the diameter *A B*, and divide it into three equal parts at *c*, and *e*, and from either of theſe points, as *e*, draw *e E*, perpendicular to *A B*, cutting the circumference at *E*, and draw *A E* and *E B*; and through the points *A* and *B*, draw *A F* and *B F*, reſpectively parallel to *E B* and *E A*, cutting each other at *F*, and *A E B F* will be a ſection of the ſtrongeſt beam that is poſſible to be cut out of the tree; *A E B F*, for the ſquare of the depth *A E* or *F B*, multiplied into the breadth *E B* or *F A*, is then the greateſt that can be produced.

From this it is plain, that the ſtrongeſt beam which can be cut out of a round tree, does not contain the moſt timber, for the greateſt rectangle that can be inſcribed in a circle is a ſquare, and therefore the ſquare *F G H I*, is greater than the rectangle *A F B E*, and yet is not the ſtrongeſt. See alſo the explanation and obſervations on *fig.* 4, from which much uſeful information may be deduced, when timber of peculiar ſtrength is wanted.

The *Compreſſion of timber* is another conſideration worth our attention.

In conſidering ſtrains of this kind, it is abſolutely impoſſible to conceive how a piece of timber that is perfectly ſtraight, can be bent, crippled or broken, by any force whatever acting at the extremes. But ſuppoſe the ſmalleſt force whatever, acting in the middle, in a direction perpendicular to the length; this force will be ſufficient to give it a ſmall degree of curvature, and if a ſtrong force be ſuppoſed to act at the ends at the ſame time, each preſſing the timber in the direction of its length, theſe forces will greatly contribute towards breaking it.

It is eaſy therefore to conceive, that if a piece of timber be the leaſt bent whatever, or if the fibres of that timber are not quite ſtraight, that there is a certain force which, if acting at the ends, will break it. Thus ſuppoſe the column *A C B*, *fig.* 9, reſting on the ground at *B*, and loaded at the top with a weight *A*, acting in a vertical direction *A B*, and if the fibres, or the piece *A C B*, is the ſmalleſt degree crooked, the degree of curva-

ture

ture by the preſſure at the two ends, will be increaſed until the fibres are bent to their utmoſt extent, and the ſmalleſt addition at the ends will break it.

The firſt author who has conſidered the compreſſion of columns with attention, is the celebrated *Euler*, who publiſhed in the Berlin Memoirs for 1757, his Theory on the Strength of Columns. The general propoſition eſtabliſhed by this Theory, is that the ſtrength of priſmatic columns is in the direct quadruplicate ratio of their diameters, and the inverſe ratio of their lengths: he proſecuted this ſubject in the Peterſburgh Commentaries for 1778, confirming his former theory. *Muſchenbroek* has compared the theory with experiment, but the compariſon has been very unſatisfactory; the difference from the theory being ſo enormous as to afford no argument for its juſtneſs, neither do they contradict it; for they are ſo very anomalous as to afford no concluſion or general rule whatever.

CONCLUSION.

THE ſtrength of materials ariſes immediately or ultimately from the coheſion of the parts of bodies. It is neceſſary to have ſome notion of that intermedium by the intervention of which an external force applied to one part of a lever, joiſt or pillar, occaſions a ſtrain in a diſtant part. This can be nothing but the coheſion between the parts, which we call ſtrength: it ſeems hardly neceſſary to ſay a tree or timber, the ſubject of the preſent diſcuſſion, is formed of numerous longitudinal fibres, which by annual growth are formed into rings, or concentric circles, and compoſing the trunk or ſtem of a tree, which by their united force of coheſion, reſiſt ſeparation, which may be called *abſolute ſtrength*, being exerted in the ſimpleſt form, and not modified by any relation to other circumſtances. The place or part where this fracture takes place, may be called the ſection of fracture.

There is a certain determinate curvature for every beam which cannot be exceeded, without breaking it; for there is a certain ſeparation of two adjoining particles, that puts an end to their coheſion. A fibre therefore can be extended only a certain determinate proportion of its length. The ultimate extenſion of the outer fibres muſt bear a certain proportion to its length; and this proportion is the ſame with that of the thickneſs (which is generally called the depth) to the radius or curvature, which is therefore determinate.

The ſection of fracture may be thus explained: that part is called the fulcrum which is the exterior part of the concave ſide in the ſection of fracture; thus the fulcrum of *fig.* 6 and 7, is at *I*, but in *fig.* 8 it is at *C*, and is the fulcrum to the lever *C B*.

When a piece of timber is breaking, that place of the timber which is in the ſame plan with the fractured part, and which ſeems to be entirely without motion is called the axis of fracture;

fracture; to explain this more fully, suppose *AB*, *fig*. 6 and 7, to be a piece of timber (viz. a joist, &c.) suspended by ropes going over publies at *C* and *D*; suppose a weight *G* to be laid on the middle, just sufficient to break it when counteracted by two weights *E* and *F*, suspended over the pullies *C* and *D*, *fig*. 6, or as in *fig*. 7, supported by two props or walls; now as the quality of the timber is more or less flexible, the curvature of the beam *A H B*, will be more or less, and just before it begins to break the fibres on the convex, or under side, *A H B*, will be much extended while those on the concave or upper side, *K I L*, will be much compressed; it is evident, therefore, there must be some line between the upper and under sides in the fracture which is at rest, or which suffers neither expansion nor compression. This line in the section of fracture is called the axis of fracture, and will be always nearest to the concave side, and more or less distant from it as the wood is harder or softer; and perhaps in general cases it will be about one-third of the total depth of the timber from the concave side. This may be considered as the reasons for what is said respecting mortices and tenons, when describing the best positions for them; for as the principal energy of the material is employed in resisting the expansion of the fibres, and occupies two-thirds of the depth or nearly so; so whatever portion of strength the other third part contributes by resisting compression, there will be no loss of strength, but rather gain, if a part is cut away, as for mortices, if the space be well filled with a hard body (See Du Hamel's Experiments), provided it be not too hard, for then it will eat into the abutting parts. For it is evident, the tendency to resist compression, will be rather increased than decreased by the foreign body thus drove in; but in cutting away the under or convex side, no foreign matter whatever can increase, nay can make up, the strength which is lost by destroying the continuity of the fibres. Further, a mechanical reason may be thus deduced:—because the same quantity of fibres if cut away from the convex side, would, if solid, make a greater resistance on the convex side, than the same number of fibres on the concave side, because the fibres on the concave side are nearer to the axis of fracture than those on the convex side; but the greater distance the fibres are from this axis, the more will they resist fracture. We wish this fact to be well considered and understood by all practical men, as it will tend to prevent many errors which may otherwise arise to the great detriment of their work. It also fully establishes the rule, that whatever is to be cut away for the purpose of mortices, &c. must be done on the concave side, which, in instances like *fig*. 6 and 7, is the upper side; but if the action of the weight or pressure is changed, as in *fig*. 8, then the mortice must be cut on the under side, which is become the concave side.

These figures 6 and 7, are shewn in positions the most common in which beams are liable to be broken by strains; the pressure on each wall is equal to half the weight of the beam and of the weight *G*; this will clearly appear by considering *fig*. 6, for the weight *G*, and the weight of the beam, must be considered as one total, for they both unite to break the beam in the same direction, and therefore the sum of the weights *E* and *F*, which act in an opposite direction, viz. on the under side, must be equal to the weight of the beam and the weight *G*, together; that is, each weight must be half, wherefore the walls which perform the same office as the weights, carrying each a half of the weight of the beam with its load *G*.

A little

A little more to illuſtrate this ſubject: *fig.* 8, is a beam ſupported by a prop *CD* in the middle, and weights *E* and *F* are hung to the ends ſufficient to break it; here the axis of the fracture will be neareſt the under edge of the beam, as that is the convex and compreſſed ſide. In this caſe it is evident that the preſſure upon the prop at *C* is equal to the weight of the beam, together with the two weights *E* and *F*; and this preſſure would be the ſame at *C*, if one half of the beam *AB*, that is *AG*, was built in a wall, and the axis of the fracture would not be varied, and the ſtrain on the upper or convex ſide *G*, by the weight *F*, would be nearly the ſame, if the end at *A* in the wall, had liberty to turn downwards; but if it is built cloſe above and below, it will ſupport a weight greater than *F*.

Addition to the Deſcription of PLATE LXXIX.

By ſome accident the following deſcription belonging to FIG. 4, PLATE 79, *was omitted*, viz. That the ſtraps at the ends of the tie-beam are not of the uſual conſtruction, but run in the direction of the beam round the ends of the rafters, and are fixed by bolting the other end of the ſtrap to the tie-beam.

FINIS.

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